SECTION 15000 GENERAL PROVISIONS FOR MECHANICAL WORK

PART 1 - GENERAL

1.01 SCOPE: The provisions of Part 1, General Documents, and DIVISION 1, General Requirements, apply to this section. These general provisions for mechanical work shall apply to all sections of DIVISION 15.

1.02 CODES AND STANDARDS: All work shall comply with the Building Codes and Ordinances of the local governmental jurisdiction. Work shall also comply with the codes and standards of the following agencies and organizations as specifically referenced hereinafter:

A. The American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME).

C. The American Society for Testing and Materials (ASTM).

D. National Fire Protection Association (NFPA).

E. National Electrical Code (NEC).

F. National Electrical Manufacturers Association (NEMA).

1.03 GUARANTEE: All equipment and systems, unless otherwise specified herein, shall be guaranteed for a period of one (1) year from the date of acceptance thereof, either for beneficial use or final acceptance, whichever is earlier. This guarantee shall be against defective materials, design and workmanship. Upon receipt of notice from the DISTRICT of failure of any part of the guaranteed equipment during the guarantee period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the CONTRACTOR.

1.04 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 STANDARD PRODUCTS: The equipment to be furnished under these specifications shall be essentially the standard products of the manufacturer. Where two (2) or more units of the same class of equipment are required under these specifications, these shall be the product of a single manufacturer.

2.02 MANUFACTURER'S DESCRIPTIVE LITERATURE: The CONTRACTOR shall, before ordering equipment, submit to the DISTRICT for approval four (4) copies of the manufacturer's descriptive literature for all equipment and materials he proposes to use to show that it meets the requirements set forth in these specifications. He shall also submit a layout plan showing the arrangement of his equipment, piping, ducts, etc. if it varies from the Contract Drawings. The DISTRICT must approve any variations.

2.03 SPECIFICATIONS AND DRAWINGS: The Contract Drawings indicate the extent and general arrangement of the mechanical systems. The specifications and Drawings shall be considered as supplementary one to the other. Materials and labor indicated, called for or implied by one and not the other shall be supplied and installed as though specifically called for in both. Equipment, ductwork and piping arrangement shall fit into

space allocated, providing clearances for servicing and maintenance. Capacities of all equipment shall be not less than those indicated on the Drawings.

2.04 ELECTRICAL WORK:

A. General: The Mechanical Contractor shall, unless otherwise specified herein, furnish all equipment specified herein with motors, motor controllers and controls. The Mechanical Contractor shall set motors in place and shall furnish motor controllers to the Electrical Contractor for installation.

B. Motors: Motors shall be built in compliance with applicable NEMA Standards and shall be in conformance with DIVISION 16. Motors shall be NEMA premium rated.

PART 3 - EXECUTION

3.01 GENERAL: Work shall be started as soon as possible. Work lines and established grades shall be in strict accordance with the Drawings. The CONTRACTOR shall be responsible for furnishing to all trades, in ample time, any information they may require to construct all bases, trenches, pits, chases and openings in floors, walls, and finishes and to provide clearances to accommodate the work. He shall set all sleeves, anchor bolts or inserts required to fasten equipment before adjacent concrete is poured.

The CONTRACTOR shall be responsible for the actions of his employees and for compliance with all laws and ordinances governing the work. He shall layout his work and establish elevations in strict accordance with the Drawings, be responsible for the accuracy of the laying out, and give his personal superintendence to the work. He shall have at all times a competent representative on the premises who shall be acceptable to the DISTRICT.

A continuous cleanup shall be maintained during the progress of the work and appointed storage areas shall be used for surplus materials and supplies. The premises shall be kept free from accumulations of waste materials and rubbish. At completion, refuse shall be removed from the site.

3.02 INTERFERENCES: The plans are generally diagrammatic and the CONTRACTOR shall harmonize the work of the different trades so that interference between piping, equipment and structural work will be avoided. All necessary offsets in piping and all fittings, etc. required to properly install the work shall be furnished complete in place. Piping, etc. shall be kept as close as possible to ceilings, walls, columns, etc., as indicated on mechanical drawings, so as to take the minimum amount of space. All offsets, fittings, etc. required shall be furnished and installed without additional expense to the DISTRICT. In case interference develops, the DISTRICT will decide which equipment shall be relocated, regardless of which apparatus was first installed.

3.03 WORKMANSHIP: All materials and equipment shall be installed in accordance with the approved recommendations of the manufacturer and the referenced standards to conform with the Contract documents and shall be subject to the approval of the DISTRICT. The installation shall be accomplished by workers skilled in the type of work involved. Workers shall have current certifications, when required, for a particular trade.

3.04 DRAWINGS: The CONTRACTOR shall prepare accurate sleeve and insert drawings for checking and approval, showing all sleeves, boxes and inserts for installation of the work covered in these specifications. The above drawings shall be prepared well in advance of the construction and be coordinated with the work of all trades.

The CONTRACTOR shall furnish the DISTRICT with "as-built" drawings. He shall keep day-to-day records of changes in locations of piping, fixtures and other items, and upon completion of the work, incorporate these changes on clean copies of the original drawings.

3.05 CONTRACTOR'S DIFFERENCES: If the CONTRACTOR proposes to deviate from the specifications or Drawings, he shall call attention to any deviations in his proposal; otherwise, it will be assumed that he accepts and agrees to follow the Contract Drawings and specifications.

3.06 VIBRATION AND NOISE CONTROL: Excessive vibration or objectionable noise created in any part of building by operation of any equipment installed under this Contract will not be permitted. CONTRACTOR shall isolate various items of equipment from building structure and take all steps that may be necessary to eliminate excessive vibration and objectionable noise produced by any equipment installed under this Contract.

3.07 EXAMINATION OF SITE: The CONTRACTOR shall examine the site and the Drawings before bidding and inform himself fully regarding the limitations of space available for the installation of materials and equipment, as well as all conditions regarding service connections, and all factors involved in his bidding and in the completion of the work.

3.08 PIPE SLEEVES: Pipe sleeves shall be provided where pipes and tubing pass through masonry or concrete walls, roofs, and partitions. Sleeves in outside walls above grade, shall be zinc-coated steel pipe. Sleeves in partitions shall be zinc-coated sheet steel having a nominal weight of not less than 0.906 pound per square foot. Plastic sleeves may be used when approved by the DISTRICT. Space between pipe, tubing, or insulation and the sleeve shall not be less than ¼-inch. Sleeves shall be held securely in proper position and location before and during construction. All sleeves shall be of sufficient length to pass through entire thickness of walls, partitions or slabs. Space between the pipe or tubing and the sleeve shall be firmly packed with oakum and caulked on both ends of the sleeve with insulating cement.

3.09 INSPECTION: Inspection shall continue during installation and testing. The right is reserved to inspect any equipment at the manufacturer's facility during or after manufacture, and to require reasonable witness tests before shipment. All equipment rejected at the manufacturer's facility shall be corrected or replaced prior to shipment. A final inspection of the equipment shall be performed prior to installation to determine conformity to the type, class, grade, size, capacity, and other characteristics specified herein or indicated. All equipment rejected shall be corrected or replaced prior to installation.

3.10 TESTS: All materials, equipment and systems that are required to be tested by these specifications or by any applicable regulation shall be tested in the presence of the DISTRICT or DISTRICT's representative. All items requiring pressure or leakage tests shall be tested before being concealed from view. All defects disclosed by tests shall be rectified and the tests repeated. The CONTRACTOR shall provide all labor, materials and equipment used for tests.

3.11 OPERATING INSTRUCTIONS: The CONTRACTOR shall submit operation instruction manuals for the DISTRICT. Manuals shall include manufacturer’s data books, parts lists, wiring diagrams, maintenance procedures and start-up/shut-down instructions. Manuals shall be provided for all equipment. The Mechanical Contractor shall also provide all necessary instruction to the DISTRICT’s personnel concerning operation of the mechanical system.

END OF SECTION

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SECTION 15001 GENERAL COMPLETION

PART 1 - GENERAL: As a prerequisite to final inspection, all construction, testing, adjustments, balancing, start up and any required instruction periods will have been completed on all mechanical systems and equipment.

1.01 AIR CONDITIONING CHILLED WATER SYSTEM:

A. All control system components shall be installed and tested for function.

B. All system testing and balancing shall be completed.

1.02 PLUMBING:

A. All plumbing system modifications shall be installed complete and all tests as required in other sections of this specification as related to the plumbing systems shall be completed.

B. Piping leak tests and correction of defects shall be complete. Operating instructions and other data required for posting shall be in place.

C. A final bacteriological test of the potable water system shall be made by a laboratory approved by the State of Florida Health Department and delivered to the District at the time of final inspection.

1.03 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS - NOT APPLICABLE.

PART 3 - EXECUTION - NOT APPLICABLE.

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SECTION 15010 PIPING

PART 1 - GENERAL

1.01 SCOPE:

A. The CONTRACTOR shall furnish and install all piping systems shown and specified, in accordance with the requirements of the Contract Documents. Each system shall be complete with all necessary fittings, hangers, supports, anchors, expansion joints, flexible connectors, valves, accessories, lining and coating, and testing to provide a functional installation.

B. Valves are specified in Section 15101 Valves and Appurtenances.

C. Piping materials are specified in Section 15251 Piping for Heating Ventilating and Air Conditioning Systems.

D. Hydronic Piping systems and Specialties are specified in Section 15183 Hydronic Piping.

E. Refrigerant piping Systems and Specialties are specified in Section 15185 Refrigerant Piping.

1.02 GENERAL:

A. See Conditions of the Contract and DIVISION 1, General Requirements, and SECTION 15020, entitled “Pipe Supports and Penetrations”, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

B. Like items of material provided hereunder shall be the end products of one manufacturer.

C. All equipment shall be properly installed, completely interconnected and placed in working order. Workmanship and materials not covered by the specifications or standards herein shall conform to the highest standards of modern practices for work of similar character.

D. Coordination with Other Work: The piping shall be installed in the most direct manner. Interference between structural features and other trades shall be avoided.

E. Workmanship: Pipe shall be cut accurately to measurements established at the structure by the CONTRACTOR and shall be installed without inducing stress into valves or fittings. Anchors and branches shall be located and installed with due consideration for pipe temperature and future expansion. Pipe shall have the burrs removed by reaming and shall be cut into proper lengths by the use of a wheel-type mechanical cutting tool or other approved device. Piping, valves, and fittings that have not been sealed at the factory shall be thoroughly cleaned with a solvent-soaked cloth or pipe brush prior to installation. Materials shall be installed in accordance with the manufacturer's recommendations. The pipe alignment shall be such that there will be no perceptible bends or kinks. Misalignment will be cause for rejection, and rework of the piping sections involved will be required.

F. All special valves, controllers, fittings, equipment, etc., shall meet the following requirements:

1. Furnished, installed, tested, and put into successful operation.

2. Be complete with all necessary miscellaneous pipe, valves, unions, fittings, auxiliaries, etc., whether indicated or not, but required.

3. Be insulated and covered in accordance with the pipe system to which they attach.

G. Furnish and install piping connected to accessories, which must vary from the drawings because of requirements peculiar to the particular equipment furnished, as required to make a complete and workable installation at no additional cost to the DISTRICT. This requirement shall include changes required in the piping systems because of design changes made by the manufacturer between the time

of design and the time of Installation or because of equipment furnished of different manufacture than that specified.

H. Furnish the necessary pipe and fittings required to install all safety and relief valves in a vertical position. Furnish and route tail pipes to a place where the discharge will not injure personnel or as indicated.

I. Where spare, replacement, or additional parts are required for the equipment specified herein, deliver these items to the DISTRICT immediately upon receipt at the jobsite. Parts shall be packaged and sealed for long storage and be securely and visibly labeled as to part, function, and name of equipment to which they apply.

J. Equip all Y-type strainers, 4 inches and larger, with blow- down valves and piping.

1.03 STANDARDS, SPECIFICATIONS, AND CODES:

A. The DISTRICT will obtain any variances imposed by site constraints.

1.04 REFERENCES:

A. American Society of Mechanical Engineers (ASME):

B. American Society for Testing and Materials (ASTM):

C. American National Standards Institute (ANSI).

1.05 SUBMITTALS:

A. Submit as specified in DIVISION 1.

B. Manufacturer's data for approval before any work is commenced.

C. When any material is specified to comply with applicable standards, codes, or laws, manufacturer's submittal must clearly state such compliance.

D. The CONTRACTOR shall submit complete shop drawings and certificates, test reports, affidavits of compliance, of all piping systems, in accordance with the requirements in the SECTION 01300 entitled, "Submittal," and as specified in the individual piping sections.

E. Data to be submitted shall include, but not be limited to:

1. Catalog Data consisting of specifications, illustrations and a parts schedule that identifies the materials to be used for the various piping components and accessories. The illustrations shall be in sufficient detail to serve as a guide for assembly and disassembly.

2. Complete layout and installation drawings with clearly marked dimensions and elevations. Piece numbers, which are coordinated with the tabulated pipe layout schedule, shall be clearly marked. Piping layout drawings shall indicate the following additional information; pipe supports, location, support type, hanger rod size, insert type and the load on the hanger in pounds.

3. Weight of all component parts.

4. Design calculations above specified.

5. Tabulated pipe layout schedule that shall include the following information for all pipefittings, service, pipe size, working pressure, wall thickness and piece number.

F. Shop Drawings:

1. The CONTRACTOR shall submit to the DISTRICT for approval, in accordance with the special clauses, complete piping drawings of each piping system as shown on the Drawings. They shall be construction drawings showing locations, dimensions, and details of all runs of piping, with pipe sizes, fittings, valves, and supports shown. The manufacturer's catalog number of all valves, hangers, supports and other items shall be submitted for approval.

2. Each shop drawing submittal shall be complete in all aspects incorporating all information and data listed herein and all additional information required to evaluate the proposed piping material's compliance with the Contract Documents. Partial or incomplete submissions will be returned to the CONTRACTOR without review.

1.06 PRODUCT STORAGE AND HANDLING:

A. Provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps in place through shipping, storage and handling to prevent pipe-end damage and eliminate dirt and moisture from inside of pipe and tube.

B. Special care in handling shall be exercised during delivery, distribution and storage of pipe to avoid damage and setting up stresses. Damaged pipe will be rejected and shall be replaced at the CONTRACTOR'S expense. Pipe and specials stored prior to use shall be stored in such a manner as to keep the interior free from dirt prior to use shall be stored in such a manner as to keep the interior free from dirt and foreign matter.

C. No pipe shall be dropped from cars or trucks to the ground. All pipes shall be carefully lowered to the ground by mechanical means. In shipping, pipe and fittings shall be blocked in such manner as to prevent damage to castings or lining. Any broken or chipped lining shall be carefully patched. Where it is impossible to repair broken or damaged lining in pipe because of its size, the pipe shall be rejected as unfit for use.

D. Where possible, store pipe, valves, fittings and equipment inside and protected from weather. Where necessary to store outside, elevate well above grade and enclose with durable waterproof wrapping.

1.07 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 GENERAL:

A. All piping shown, but not sized on the Contract Drawings, shall be properly sized for the function to be performed. Valve types to be used are herein specified and shown on the Contract Drawings for their respective systems.

B. Pressure Rating: All piping systems shall be designed for the maximum expected pressure as defined on the Piping Schedule shown at the end of this section.

C. The materials to be used for the piping systems shown on the Drawings are listed in Specification Section 15251 Piping for Heating and Air Conditioning Systems.

2.02 ACCEPTABLE MANUFACTURERS: Manufacturers and model numbers specified herein are to establish quality and performance only. Products of manufacturers regularly engaged in their manufacture are

acceptable if proven to the DISTRICT as equal or better quality and performance and as stated in the General Conditions.

2.03 PIPING REQUIREMENTS: The materials to be used for the piping systems shown on the Drawings are listed in Specification Section 15251 Piping for Heating and Air Conditioning Systems**.**

2.04 JOINTS:

A. Flanged Joints: Flanged joints shall be made up with full-face gaskets as specified in the piping paragraphs. Flange faces shall have a uniform bearing on the gaskets. Flanges shall be drawn together uniformly until the joint is tight. No washers shall be permitted for the bolt and nut assemblies. The length of the bolts shall be uniform and in accordance with the standards specified herein. The bolt's maximum projection beyond the end of the nut shall be 0.25-inch nor shall the bolt fall short of the end of the nut.

1. Flanges: Where the design pressure is 125 psi or less, flanges shall conform to either ANSI/AWWA C115/A21.15 Class D or ASME B16.1 125-lb class. Where the design pressure is greater than 150 psi, up to a maximum of 250 psi, flanges shall conform to either ANSI/AWWA C115/21.15 or ASME B16.1 250-lbs class. Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise shown. Attachment of the flanges to the pipe for miscellaneous small pipes shall be in accordance with the standards specified for these pipes.

2. Blind Flanges: Blind flanges shall be in accordance with ANSI/AWWA C207, or with the standards for miscellaneous small pipes. All blind flanges for pipe sizes 12-inches and over shall be provided with lifting eyes in the form of welded or threaded eyebolts.

3. Flange Coating: All machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

4. Flange Bolts: If studs are required, they shall be in accordance with ASTM A 307, Grade B, with heavy hex nuts. Machine bolts shall normally be used on all flanged connections and shall be in accordance with ASTM A 307, Grade A, with hex nuts. For corrosive areas use Type 316 stainless steel, ASTM A193 Grade B 8M hex head bolts & ASTM A194, Grade 8M hex head nuts.

5. If studs are required, they shall extend through the nuts a minimum of **[ ]**-inch. All bolts and nuts shall conform to Section entitled "Miscellaneous Metalwork."

6. Flange Gaskets: Gaskets for flanged joist shall be of materials as specified in piping sections. Blind flanges shall have gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be permitted.

7. Flange Gasket Suppliers, or equal:

a. John Crane, style 2160.

b. Carlock, style 3000.

B. Welded Joints:

1. Welded joints shall be shop-fabricated in accordance with the standards and specifications contained herein.

2. Field welding will be permitted for black carbon steel pipe where it can be demonstrated that the interior of the pipe can be satisfactorily lined and inspected. Welding in the field shall be performed only when requested on the shop drawings and accepted by the DISTRICT in writing as specified herein.

3. All welding shall be performed in accordance with ANSI/ASME B31.1 and AWWA C206 except as modified or supplemented herein. All welders shall be AWS certified in accordance with AWWA C206, and ANSI/ASME B31.1 requirements.

4. Pipe and fittings with wall thickness of 3/16-inch and larger shall have ends beveled for welding. Bevels shall be 30° with a maximum of 37°. The abutting pipe ends shall be separated before welding to permit complete fusion to the inside wall of the pipe without overlapping. Welding shall be continuous around the joint and shall be completed without interruption. Welds shall be of the single vee butt type, of sound weld metal thoroughly fused into the ends of the pipe and into the bottom of the vee. Welds shall be free from cold spots, pinholes, oxide inclusion, burrs, snags, rough projections or other defects.

5. Filler metal for welding shall be of the same composition as the base metal. All welding of steel pipe flanges shall be in accordance with requirements of AWWA C207 and ANSI/ASME B31.1.

6. Field repairs of cement motor lining a welded joints shall be made in accordance with AWWA C205 Appendix A or AWWA C602.

7. Field welds shall be "fixed position" type.

8. All field welds shall be radiographically inspected by the CONTRACTOR if so ordered by the DISTRICT.

C. Threaded Joints:

1. All threads shall be clean, machine cut and all pie shall be reamed before erection. Taps and dies shall be cleaned, sharpened and in good condition. All threaded joints shall be made tight with Teflon tape.

2. After having been set up, a joint shall not be backed off unless the joint is broken, the threads cleaned and new tape applied.

2.05 PIPING SPECIALTIES:

A. Gaskets:

1. Rubber gaskets for flanged joints, ASTM D1330:

2. 1/16-inch thick full-faced red rubber for all pipe sizes 10 inches and smaller.

3. 1/8-inch thick full-faced red rubber for all pipe sizes 12 inches and larger.

4. 1/16-inch thick full-faced neoprene or equal for fuel oil and natural gas service.

5. Furnish with bolt holes and pipe openings punched.

B. Flange Bolt Thread Lubricant: An anti-seize compound and thread lubricant designed for 1,000 degrees F.

C. Backing Rings for Butt-Welded Joints: Be machined split ring with knock-off spacer nubs for use in pipe having wall thickness 1/2-inch or less.

D. Instrument Needle Valves:

1. 3,000-pound bronze, globe or angle needle or Kel-F, stainless-steel stem, "O" ring or Teflon seal and screwed ends. Hoke Series 300 or Whitey. Install an instrument needle valve with each pressure gauge.

2.06 METERS AND GAUGES:

A. General:

1. Provide all instruments, meters, gauges, and thermometers, complete with interconnecting tubing, piping, valves as specified and as indicated.

2. Provide gauge cock in the piping for all instruments, meters, and gauges, both at point of takeoff and at the instruments, meters and gauges. Gauge cock shall be of the same design requirements as the lines they serve.

B. Thermometers:

1. Trerice CX9 or Ashcroft

2. Liquid in glass type.

3. Adjustable angle type with a 12 inch scale.

4. Cast aluminum case with epoxy powder coating.

5. Stainless steel stem.

6. Include thermowells and accessories.

7. Range – 0 to 100F

C. Indicating Pressure Gauges:

1. Ashcroft "Duragauge" Crosby or Marsh.

2. Bourdon Tube:

a. 160-psi Maximum Graduation: Grade A phosphor bronze, brazed joints stress relieved.

3. Socket and Tip:

a. 160-psi Maximum Graduation: Forged bronze.

4. Case: High-impact glass-fiber-reinforced polypropylene, weatherproof with safety blowout discs or release back plate.

5. Ring: Bayonet-locking type.

6. Movement: All stainless steel mounted on socket with milled teeth on pinion and sector.

7. Dial: 4-1/2 inches, white laminated phenol with black markings.

8. Pointer: Aluminum with micrometer adjustment.

9. Accuracy: 1/2 of 1 percent over full range of scale.

10. Range: As shown on the drawings or as required for the pressure range to be measured.

11. Mount all pressure gauges on rigid surfaces. Install an instrument needle valve with each gauge.

12. Be solid-front type recalibrated from back without removing dial.

2.07 PIPE INSULATION:

A. Chilled water and cold water make-up piping shall be insulated as shown on the Drawings and as specified in Specification Section 15080 Mechanical Insulation.

2.08 PIPE SUPPORTS:

A. Pipe support materials in the chiller and condenser enclosures shall be galvanized steel. Where copper piping is used, copper or copper plated supports shall be provided.

B. Pipe support materials in the EOC shall be standard materials.

2.09 PIPE IDENTIFICATION PAINTING:

A. All exposed and non-submerged pipe, including insulated pipe, shall be painted, color coded, and labeled.

PART 3 - EXECUTION

3.01 GENERAL:

A. The CONTRACTOR shall furnish all labor, tools, materials, and equipment necessary for installation and jointing of the pipe. All piping shall be installed in accordance with Drawings in a neat workmanlike manner and shall be set for accurate line and elevation. All piping shall be thoroughly cleaned before installation, and care shall be taken to keep the piping clean throughout the installation.

B. Furnish and install sleeves for all pipes passing through concrete floors, and walls as noted in Section 15020.

C. Before setting wall sleeves, pipes, castings and pipes to be case in place, the CONTRACTOR shall check the Drawings and equipment manufacturer's drawings which may have a direct bearing on the pipe locations. The CONTRACTOR shall be responsible for the proper location of the pipes and appurtenances during the construction of and renovation of the tanks and structures.

D. All connections to equipment shall be made with unions or flanges. Piping shall be attached to pumps, valves, equipment, etc., as shown on the drawings and in accordance with the respective manufacturers' recommendations.

E. For piping assembled with threaded, solvent cemented, welded or soldered joints, liberal use of unions shall be made. Unions shall be provided close to main pieces of equipment and in branch lines to permit ready dismantling of piping without disturbing main pipe lines or adjacent branch lines. A minimum of one union per straight run of pipe between fitting and/or valves with multiple lengths of pipe shall be used.

F. All changes in directions or elevations shall be made with fittings.

G. The design drawings are generally diagrammatic. They do not show every bend, off-set, elbow or other fitting that may be required in the piping for installation in the space allotted. Careful coordination of the work of this section with that of all Divisions is necessary to avoid conflicts.

H. Jointing Pipe:

1. Threaded Pipe: Ream all pipe after cutting and before threading. Use non-hardening pipe compound "Tite-Seal" on male threads only.

2. Copper Tube: Ream all pipe after cutting and polish end to be soldered.

3. Provide nipples of same material and weight as pipe used. Provide extra strong nipples when length of unthreaded part of standard weight nipple is less than 1-1/2 inches.

4. Provide reducing fittings where changes in pipe sizes occur.

5. Provide dielectric unions or flanges between copper and steel piping and between brassware and steel. Do not use steel and copper piping in the same system without such isolation.

I. Unions or Flanges: Provide unions or flanges in all service lines at each piece of equipment, specialty, valves, or at other locations required for ready disconnect.

J. Coordinate with the other trades before installation of materials.

K. Properly align, adjust and lubricate all equipment before final acceptance.

L. Provide vents and drains at high and low points of water system.

M. Provide dielectric-type unions where copper piping is connected to ferrous material.

N. Test, flush and balance all system. Install all vents, test tees, test connections and other items required by local practice, codes, and regulations.

3.02 PIPING INSTALLATION:

A. Pipe and Fittings:

1. Install pipe and fittings in accordance with recognized industry practice which all achieve permanently leak-proof piping systems, capable of performing each indicated service without piping failure.

2. Install each run with a minimum of joints and couplings, but with adequate and accessible unions for disassembly and maintenance or replacement of valves and equipment.

3. Reduce sizes where indicated by use of reducing fittings.

4. Align pipe accurately at connections within 1/16-inch misalignment tolerance.

5. Comply with ASME - Code for Pressure Piping.

6. Locate piping runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible.

7. Orient horizontal runs parallel with walls.

8. Locate runs as indicated or described by diagrams, details and notations or, if not otherwise indicated, run piping in the shortest route which does not obstruct usable space or block access for servicing the building and its equipment.

9. Hold piping close to walls, overhead construction, columns and other structural and permanent-enclosure elements of the building.

a. Limit clearance to 0.5 inch where furring is shown for enclosure or concealment of piping but allow for insulation thickness if any.

10. Wherever possible in finished and occupied spaces, conceal piping from view by locating in column enclosures, in hollow wall construction or above suspended ceilings.

a. Do not encase horizontal runs in solid partitions except as indicated.

B. Piping System Joints:

1. Provide joints of the type indicated in each piping system.

2. Threaded Joints:

a. Thread pipe in accordance with ASME B1.20.1.

b. Cut threads full and clean using sharp dies.

c. Ream threaded ends to remove burrs and restore full inside diameter.

d. Apply pipe joint compound or pipe joint tape (Teflon) on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

3. Welded Joints:

a. Weld pipe joints in accordance with ASME Code for Pressure Piping.

b. Install forged branch-connection fittings wherever branch pipe is indicated or install regular "T" fitting unless indicated otherwise.

4. Flanged Joints:

a. Match flanges within piping system and at connections with valves and equipment.

b. Clean flange faces and install gaskets.

c. Tighten bolts to provide uniform compression of gaskets.

C. Cleaning and Protection:

1. Clean exterior surfaces of installed piping system of superfluous materials and prepare for application of specified coatings or insulation.

2. Unless otherwise specified, flush out piping systems with clean water for a minimum of 10 minutes before proceeding with required tests.

3. Inspect each run of each system for completion of joints, supports and accessory items.

3.03 PIPE PROTECTIONS:

A. Coat all exposed threads on galvanized steel pipe with two coats of zinc chromate after assembly.

B. Provide dielectric isolation between pipes and metal parts of structure.

3.04 PIPING, VALVES AND FITTINGS:

A. Changes in supply-main sizes shall be made through eccentric reduced fittings. Pipe shall be cut to measurements established at the project site and shall be worked into place without springing or forcing, clearing all windows, doors, and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installations will not be permitted. Pipe burrs shall be removed by reaming. Pipe supports shall permit free expansion and contraction without damage to joints or hangers. Changes in direction shall be made with fittings. Piping connections to equipment shall be as indicated. Open ends of pipelines or equipment shall be properly capped or plugged during installation to keep dirt and other foreign material out of the system. Taps for pressure gage connections shall be provided with a nipple and a shutoff gage cock.

B. Joints and Fittings: Mitering of pipe to form elbows, notching straight runs to form tees, or similar construction will not be permitted. Flanged joints shall be faced true, gasketed, and made up of square and tight. Gaskets shall be factory cut in one-piece 1/16-inch thick.

1. Threaded: Pipe threads shall be full and cleanly cut with sharp dies. Not more than three (3) threads at each pipe connection shall remain exposed after installation. Ends of pipe shall be reamed, after threading and before assembly, to remove all burrs.

2. Flanged: Flange bolts shall be tightened sufficiently to slightly compress the gasket and effect a seal, but not so tight as to distort the flanges.

3. Welded: Welding shall conform to the specifications and recommendations contained in the "Code for Pressure Piping," ANSI/ASME B31.1.

C. Pipe Sleeves: Pipe passing through masonry construction shall be fitted with sleeves. Each sleeve shall extend through its respective wall, or other masonry structure, and shall be cut flush with each surface unless otherwise specified. Unless otherwise specified, the inside diameter of the pipe sleeves shall in all cases be at least 1/2-inch larger than the outside diameter of the passing pipe or pipe covering. Sleeves shall be steel pipe, cast iron pipe, or terra-cotta pipe. Unless otherwise specified, piping passing through exterior walls shall be made dust-tight and gas-tight with special rubber gasketed sleeve and joint assemblies, or with sleeves sealed with modular rubber sealing elements, or sealed by caulking with oakum and sealing with polysulfide or urethane sealant.

D. Valve Tags: Identification tags of brass or aluminum shall be provided for all valves. Tags shall be approximately 2 inches in diameter with markings stamped and spelled out in full and shall be secured to the valves with No. 12 AWG copper wire or plastic ties.

E. Piping Supports: Expansion anchors shall be used to fasten supports to existing concrete and masonry.

1. Design loads for inserts, brackets, clamps, and other support items shall not exceed the manufacturer's recommended loads.

2. Piping in the chiller and condenser enclosures shall be supported from the floor. Support materials in these locations shall be galvanized steel.

3. Piping in the EOC shall be conventionally supported. Support materials in these locations shall be steel.

4. Pipe supports shall be manufactured for the size and type of pipe to which they are applied. Strap hangers will not be acceptable. Threaded rods shall have sufficient threading to permit the maximum adjustment available in the support item.

5. Anchorage shall be provided to resist thrust due to temperature changes, changes in diameter or direction, or dead-ending. Anchors shall be located as required to force expansion and contraction movement to occur at expansion joints, loops, or elbows, and as required to prevent excessive bending stresses and opening of mechanical couplings. Anchorage for temperature changes shall be centered between elbows and mechanical joints used as expansion joints.

3.05 INSTALLATION OF EXPOSED PIPING:

A. All pipe flanges shall be set level, plumb, and aligned. All flanged fittings shall be true and perpendicular to the axis of the pipe. All bolt holes in flanges shall straddle vertical centerline of pipes.

B. Unions shall be installed where required for piping or equipment installation, even though they are not shown on the Drawings.

C. Piping shall be installed without springing or forcing the pipe in a manner that would set up stresses in the pipe, valves, or connected equipment.

D. Required straight runs of piping upstream and downstream of flow measuring devices shall be smooth.

E. Where valve hand wheels are shown, valve orientation shall be as shown. Where valve hand wheels are not shown, valves shall be oriented to permit easy access to the hand wheels, and to avoid interferences.

3.06 INSTALLATION OF FLEXIBLE COUPLINGS AND SERVICE SADDLES:

A. Prior to installation, thoroughly clean oil, scale, rust, and dirt from the pipe to provide a clean seat for the gasket. Care shall be taken that the gaskets are wiped clean before they are installed. If necessary, flexible couplings may be lubricated with soapy water or manufacturer's standard lubricant before installation on the pipe ends. Install in accordance with the manufacturer's recommendations. Bolts shall be tightened progressively, drawing up uniform tightness. Workmen tightening bolts shall use torque-limiting wrenches.

3.07 VENTS AND DRAINS:

A. Vent the high point and drain the low point of all pipelines, whether shown on the Drawings or not, with 3/4-inch gate valves on those pipelines 2-1/2 inches and larger and 1/2-inch gate valves on those pipelines 2 inches and smaller. Valve types shall be as shown in the Valve Schedule described in Section Valves and shown on the Drawings. Where gate valves do not appear in the Valve Schedule for a service listed, Type V102 valves shall be used.

3.08 PIPE CLEANING:

A. Interim Cleaning: Care shall be exercised during fabrication to prevent the accumulation of weld rod, weld spatter, pie cuttings and filings, gravel, cleaning rags, etc. within the piping sections. All piping shall be examined to assure removal of these and other foreign objects prior to assembly. Shop

cleaning may employ any conventional cleaning method if it does not corrode, deform, swell, or otherwise alter the physical properties of the material being cleaned.

B. Final Cleaning: Following assembly and testing and prior to final acceptance, all pipelines installed under this section shall be flushed with water and all accumulated construction debris and other foreign matter removed. Flushing velocities shall be a minimum of 2.5 feet per second. Cone strainers shall be inserted in the connections to attached equipment and left there until cleaning has been accomplished to the satisfaction of the DISTRICT. Accumulated debris shall be removed through drains 2 inches and larger or by dropping spools and valves.

3.09 TESTING:

A. Conduct pressure and leakage tests on all newly installed pipelines. Furnish all necessary equipment and material and make all taps in the pipe, as required. Test pressure shall be as specified in the Piping Schedule shown herein.

B. All leak tests as required in other sections of this specification or tests required by the latest edition of Standard Building Code shall be completed and witnessed by the DISTRICT prior to any application of insulation or wrapping of pipe or backfilling of pipe in trenches. CONTRACTOR shall present a letter of certification indicating completion of such tests signed by an authorized representative of the CONTRACTOR.

C. Preparation and Execution:

1. Exposed Pressure Piping: Conduct the tests on exposed piping after the piping has been completely installed, including all supports, hangers, and anchors.

D. Hydrostatic Leak Tests:

1. Equipment: Furnish the following equipment for the hydrostatic tests:

Amount	Description
2	Graduated Containers
2	Pressure Gauges
1	Hydraulic Force Pump
	Suitable Hose and Suction Pump as Required

2. Procedure: Water shall be used as the hydrostatic test fluid unless otherwise specified. Test water shall be clean and shall be of such quality as to minimize corrosion of the materials in the piping system. Vents at all high points of the piping system shall be opened to purge air pockets while the piping system is filling. Venting during the filling of the system also may be provided by the loosening of flanges having a minimum of four bolts or by the use of equipment vents. All parts of the piping system shall be subjected to the test pressure specified in the Piping Schedule. The hydrostatic test pressure shall be continuously maintained for a minimum time of 30 minutes and for such additional time as may be necessary to conduct examinations for leakage. Examination for leakage shall be made at all joints and connections. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking. Any visible leakage shall be corrected at the CONTRACTOR'S sole expense.

E. Initial Service Leak Tests:

1. Equipment: Equipment used for initial service leak test shall be performed by gradually bringing the piping system up to normal operating pressure and holding it there continuously for a minimum time of 10 minutes. Examination for leakage shall be made at all joints and connections. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking. Any visible leakage shall be corrected at the CONTRACTOR'S sole expense.

F. Hydraulic Testing of Pipelines:

1. Unless otherwise provided herein, water for testing pipelines will be furnished by the DISTRICT; however, the CONTRACTOR shall make all necessary provisions for conveying the water from the DISTRICT-designated source to the points of use.

2. Prior to hydrostatic testing, all pipelines shall be flushed or blown out as appropriate. The CONTRACTOR shall test all pipelines either in sections or as a unit. No section of the pipeline shall be tested until all field-placed concrete or mortar has attained an age of 14 days. The test shall be made by closing valves when available, or by placing temporary bulkheads in the pipe and filling the line slowly with water. The CONTRACTOR shall be responsible for ascertaining that all test bulkheads are suitable restrained to resist the thrust of the test pressure without damage to, or movement of, the adjacent pipe. Care shall be taken to see that all air vents are open during filling.

3. The pipeline shall be filled at a rate that will not cause any surges or exceed the rate at which the air can be released through the air valves at a reasonable velocity and all the air within the pipeline shall be properly purged. The CONTRACTOR is responsible for removing all air in the piping to be tested by whatever means is necessary including addition of temporary air vent piping and valving.

4. After the pipeline or section thereof has been filled, it shall be allowed to stand under a slight pressure for at least 24 hours to allow the concrete or mortar lining, as applicable, to absorb what water it will and to allow the escape of air from any air pockets. During this period, bulkheads, valves, and connections shall be examined for leaks. If leaks are found, corrective measures satisfactory to the DISTRICT shall be taken.

5. The hydrostatic test shall consist of holding the test pressure on the pipeline for a period of 4 hours. The test pressure for distribution and transmission pipelines shall be 150 percent of the pipe system design pressure or 25 psig. The maximum allowable leakage for pipelines shall be 20 U.S. gallons per inch of diameter per mile of pipe per 24 hours for pipe with 20 ft. or less joint lengths. All visible leaks shall be repaired in a manner acceptable to the DISTRICT.

G. Test Records: Records shall be made of each piping system installation during the test. These records shall include:

1. Date of Test.

2. Description and Identification of Piping Tested.

3. Test Fluid.

4. Test Pressure.

5. Remarks, to include such items as:

a. Leaks (type, location).

b. Repairs made on leaks.

6. Certification by CONTRACTOR and signed acknowledgement by the DISTRICT.

3.10 CORROSION PROTECTION:

A. Atmospheric Exposed Piping and Accessories: All atmospheric exposed surfaces of black and hot-dip galvanized steel, brass, copper, and bronze piping components including, but not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves and fasteners shall be painted in accordance with Section 09900, as applicable to the base metal material.

3.11 PIPE PAINTING:

A. Painting of piping systems shall be as specified in SECTION 09900 Protective Coatings.

3.12 CLEANUP:

A. After completion of the work, all remaining pipe cuttings, joining and wrapping materials, and other scattered debris, shall be removed from the site. The entire piping system shall be handled over in a clean and functional condition.

END OF SECTION

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SECTION 15020 PIPE SUPPORTS AND PENETRATIONS

PART 1 - GENERAL

1.01 SCOPE:

A. The Work of this Section shall consist of furnishing all labor, material, and equipment for the installation of plant piping as shown on the Drawings and specified herein.

1.02 GENERAL:

A. Like items of material provided hereunder shall be the end products of one manufacturer.

B. See Conditions of the Contract and DIVISION 1, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

C. CONTRACTOR shall design, furnish and install a complete system of pipe supports for the piping systems provided under this Contract. The CONTRACTOR shall provide for piping expansion and contraction and anchoring as necessary. Contact between dissimilar metals shall be prevented.

1.03 REFERENCES:

A. American Society of Mechanical Engineers (ASME):

1. B31.1 - Power Piping

B. Manufacturers Standardization Society (MSS):

1. SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture

2. SP-69 - Pipe Hangers and Supports - Selection and Application

1.04 SUBMITTALS:

A. Submit as specified in DIVISION 1.

B. Submit manufacturer's data for approval before any work is commenced.

C. When any material is specified to comply with applicable standards, codes, or laws, manufacturer's submittal must clearly state such compliance.

1.05 MATERIAL DELIVERY, STORAGE, AND PROTECTION:

A. All materials shall be delivered in a clean and undamaged condition and stored off the ground, to provide protection against oxidation caused by ground contact. All defective or damaged materials shall be replaced with new materials.

1.06 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Pipe Supports: All pipes shall be adequately supported in accordance with the requirements of this section and as shown on related drawings.

2.02 PIPING SUPPORT SYSTEMS:

A. General:

1. The CONTRACTOR shall design and install the necessary pipe supports to support the chilled water system and refrigerant system piping. All piping in the chiller and condenser enclosures shall be supported from the floor. No piping shall be supported from the grating structure or walls. Pipe support materials in the chiller and condenser enclosure and other outdoor locations shall be galvanized steel.

2. All support anchoring devices, including anchor bolts, inserts and other devices used to anchor the support onto a concrete base, roof, wall or structural steel works, shall be of the proper size, strength and spacing to withstand the shear and pullout loads imposed by loading and spacing on each particular support.

3. Detailed shop drawings of all supports, including support-anchoring devices, shall be supplied with the submittals specified hereinbefore.

4. Where piping connects to equipment it shall be supported by a pipe support and not by the equipment.

5. Pipe support system components shall withstand the dead loads imposed by the weight of the pipes filled with water. Commercial pipe supports and hangers shall have a minimum safety factor of 5.

B. Piping:

1. Pipe hangers and supports shall meet the requirements of Section 5, Chapter II of ANSI B31.1 and shall be types as given for MSS Standard Practice SP-58 and SP-69.

2. Constant Support, Spring and Rigid Hangers: Bergen, Blaw-Knox, Fee and Mason, Grinnell or NAVCO.

3. Pipe hanger and supports shall be of the types listed in Table 1 "Hanger and Support Selection," MSS Standard Practice SP-69 except that the following figure types given in Figure 1 will not be acceptable: Types 5, 6, 11, 12, 7, 9, 10 and 25.

4. Horizontal piping shall be supported with adjustable swivel-ring, or Clevis type hangers as shown, Grinnell Figure 104; Elcen Figure 92; or equal.

5. Pedestal pipe supports shall be adjustable, with stanchion, saddle, and anchoring flange as shown, Grinnell Figure 264; Elcen Figure 50; or equal. Provide a neoprene waffle isolation pad under anchoring flanges, adjacent to equipment or where otherwise required to provide vibration isolation. Pads shall be Mason Industries, Inc. Type W; Korfund Korpad 40; or equal.

6. Horizontal piping hanger support rods shall attach to steel beams with C-clamps or beam clamps; to concrete with inserts, brackets or flanges fastened with flush shells.

7. All hangers, rods, clamps, protective shields, metal framing support components, and hanger accessories shall be galvanized unless copper plates or noted otherwise on the Drawings.

8. Unless noted otherwise on the Drawings, horizontal pipe support or hanger spacing and hanger rod sizing for steel and ductile iron pipe shall be as follows:

Pipe Size	Maximum Support and Hanger Span Hangers	Minimum Rod Size Single Rod
1 inch & smaller	6 feet	1/4-inch
1-1/4 inches thru 2-1/2”	8 feet	1/4-inch
3” thru 6'	8 feet	3/8-inch

9. Vertical sway bracing shall be provided where shown, or on 10' maximum centers.

C. Concrete Inserts and Expansion Shields:

1. The load rating for universal concrete inserts shall not be less than that of the hanger rods they support.

2. Type A:

a. Unistrut Corporation, Series P-3200 inserts or Brinkley Company.

b. Inserts shall be galvanized and have a recommended load capacity of 2,000 pounds per foot of length in average good concrete with a safety factor of 3.

c. Inserts shall be continuous and located as required.

d. Provide end caps at each end. End caps shall have attached anchor if spacing from end of insert to next anchor is greater than 2 inches.

e. Inserts shall be 5-5/8 inches wide outside by 1-3/8 inches deep outside and constructed of minimum 12-gauge galvanized steel, adequate for a 7/8-inch rod and nut.

f. CONTRACTOR shall furnish Unistrut galvanized nuts with or without springs required for work under this contract.

3. Type B: Concrete inserts shall be malleable iron Type 18 listed in MSS Standard Practice SP-69, Grinnell, Fig. 282 or Fee and Mason.

4. Type C: Concrete inserts shall be malleable iron, Grinnell Fig. 152, Fee and Mason or approved equal.

D. When necessary to use expansion anchors, they shall conform to DIVISION 5.

E. All piping shall be supported in a manner that will prevent undue strain on any valve, fitting, or piece of equipment. In addition, pipe supports shall be provided at changes in direction or elevation, adjacent to flexible couplings, and where otherwise shown. Pipe supports and hangers shall not be installed in equipment access areas or monorail runs.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. General:

1. Furnish all labor, materials and equipment necessary to make a complete installation as indicated and specified.

2. Provide all necessary supports, brackets or foundations for properly installing all equipment.

3. Coordinate with the other trades before installation of materials.

4. Provide sleeves and flashings for all piping penetrating walls or the roof. Provide all required openings in walls and floors.

3.02 HANGERS, SUPPORTS AND ANCHORS:

A. General:

1. The design, selection, spacing and application of pipe hangers, supports and anchors shall be in accordance with the codes and standards specified except the ANSI B31.1 - Code for Power Piping shall take precedence over the MSS SP-69 standard.

2. Hanger class and selection of components shall be in accordance with those specified.

3. Furnish and install all rigid and spring supports, whether or not they are shown and detailed, but are required to adequately support the piping system.

4. Furnish and install for all pipe installed under this contract.

5. Include all necessary structural steel, brackets, concrete inserts, etc., which are not a part of the building, or specified, but required to properly support the piping systems.

6. Include necessary temporary supports, pins, etc., for the hydrostatic testing of steam lines and other lines that are spring supported.

7. Install piping and provide necessary supports and anchors to prevent the forces and mounting imposed on equipment from exceeding the limits specified by the equipment manufacturer.

8. Unless shown otherwise, piping shall be parallel to building lines. Hangers on adjacent piping shall be aligned where possible on common size ranges.

9. CONTRACTOR shall note that a maximum rod size of 7/8 inch can be used with Type A concrete inserts. Maximum horizontal pipe hangers and support spacing shall be reduced for 14-inch and larger lines supported from new and existing Unistrut P-3200 type concrete inserts.

B. Adjustment:

1. Prior to putting the piping systems into service, adjust all spring hangers to the correct cold load, adjust all solid hangers to correct position and remove all temporary hangers used in erection and testing.

2. After and during the time the piping systems are being put into service, adjust all spring hangers for the current hot load and align all hanger rods to the vertical position.

END OF SECTION

SECTION 15080 - MECHANICAL INSULATION

PART 1 - GENERAL

1.01 SCOPE

A. The Work of this Section shall consist of furnishing all labor, materials, tools, equipment, accessories, and services necessary for providing and installing mechanical insulation of all items as shown on Drawings and/or specified herein. All sizing required for preparation of painting shall be performed under this Section.

B. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1, including Section 01600, apply to Work of this Section.

1.02 SUBMITTALS

A. Submit in accordance with DIVISION 1, Shop Drawings covering the items included under this Section. Shop Drawing submittals shall include:
   1. Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. CONTRACTOR shall furnish ENGINEER for approval a list of insulating materials and thickness for items listed on Schedule. The list shall be complete including all types and thicknesses of insulation used for the various services as well as the limits of Work.

1.03 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics, and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.
   1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to Site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage in accordance with manufacturer’s recommendations. Do not install damaged or wet insulation; remove from Site.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:
   1. Cellular glass insulation:
      a. Pittsburgh Corning

b. Engineer Approved Equal

2. Flexible elastomeric thermal insulation:
   a. Armstrong – Armaflex
   b. Manville – Aerotube
   c. Rubates
   d. Engineer Approved Equal

2.02 MATERIALS- CELLULAR GLASS INSULATION

A. Insulation material shall be cellular glass insulation manufactured in accordance with ASTM C552, "Standard Specification for Cellular Glass Thermal Insulation" or EN14305, "Thermal insulation products for building equipment and industrial applications – factory made cellular glass products (CG) products Specification" by Pittsburgh Corning. The manufacturer's quality system for manufacturing, inspecting and testing cellular glass insulation shall be certified to meet the requirements of ISO 9001:2008. Cellular glass pie insulation shall be fabricated according to the requirements of ASTM C1639 "Standard Specification for Fabrication of Cellular Glass Pipe and Tubing Insulation", DIN EN 13167 or AGI Q 137.

B. Joint sealant shall be provided in accordance with the insulation manufacturer's recommendations and be similar to one the following.

   1. Butyl sealant used for sealing joints in cellular glass insulation systems, similar to PITTSEAL 444N Sealant as supplied by Pittsburgh Corning or Engineer Approved equivalent.

   2. A high performance, MS Polymer based sealant used for sealing joints in cellular glass insulation systems on chilled water systems, similar to PITTSEAL CW Sealant as supplied by Pittsburgh Corning or Engineer Approved equivalent.

   3. A single component cold bituminous adhesive used to seal longitudinal and circumferential joints of cellular glass insulation in chilled water lines similar to PC 18 adhesive as supplied by Pittsburgh Corning or Engineer Approved equivalent.

C. Insulation jacketing shall be provided in accordance with the Manufacturer's recommendations and include the following.

   1. For indoor applications, a non-cellulose multiply laminated fiberglass- reinforced polypropylene, PVC, or vinyl faced/metalized film backed jacket shall be used. The jacket must not contain known mold or mildew nutrients, and exhibit no mold when tested according to ASTM C1338 "Determining Fungi Resistance of Insulation Materials and Facings".

   2. For outdoor applications, 0.016 in. minimum aluminum jacketing with bands with matching seals shall be used.

D. Metal bands shall be aluminum with matching seals. Band dimensions shall be a minimum of 0.5 x 0.020 for piping and equipment with O.D. up to 48" and 0.75 x 0.020 for larger O.D.

E. Tape shall be a minimum or 0.75 wide high tensile strength, fiber reinforced tape.

F. Weather barrier mastic shall be a flexible, acrylic latex weather barrier coating formulated for use with cellular glass insulation, similar to PITTCOTE 404 coating as supplied by Pittsburgh Corning or Engineer Approved equivalent.

G. Reinforcing mesh fabric for weather barrier coating shall be synthetic fabric, 6.5 x 6 mesh, similar to PC Fabric 79 as supplied by Pittsburgh Corning or approved equivalent.

H. Vapor retarder mastic finish/surface filler shall be a vapor and weather barrier asphalt coating especially formulated for use with cellular glass insulation, similar to PITTCOAT 300 finish supplied by Pittsburgh Corning or Engineer Approved equivalent.

I. Bore coating at pipe supports shall be one of the following:

1. Any commercially available polyurethane varnish.

2. Hydrocal B-11which is a reactive gypsum product that is mixed with water to form an inorganic, non-combustible bore coating.

2.03 MATERIALS- ELASTOMERIC THERMAL INSULATION

A. Insulation material shall be flexible tubing elastomeric thermal type with a minimum density of 5.5 pcf. Adhesives shall be recommended by the insulation manufacturer. Indoor and outdoor shall be piping insulation shall be finished by applying two coats of protective insulation coating as recommended by the insulation manufacturer. The protective coating color shall match the existing coatings on the refrigerant piping insulation.

PART 3 - EXECUTION

3.01 ACCEPTABLE INSTALLERS

A. Installer's Qualifications: Firm with at least 3 years successful installation experience on projects with mechanical insulations similar to that required for this Project.

3.02 INSPECTION

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.03 INSTALLATION

A. The Mechanical Insulation Schedule gives the application, type, temperature, and thickness of insulation required. This Schedule should be used with the following interpretations.
   1. Insulation thickness selection not shown on Schedule shall be based on the ASHRAE Standard for the conditions of 80 degrees F ambient air temperature with 80 percent relative humidity indoor, and –20 degrees F ambient air temperature with 90 percent relative humidity outdoor, with operating temperatures as listed on Schedule.
   2. Cellular glass insulation thickness shown on Schedule is based on a k-factor of 0.31 at 50 degrees F. Insulation thickness may be increased or decreased in direct proportion to the k-factor of the insulation material furnished.

3.04 HVAC PIPING SYSTEM INSULATION

A. Sub-Freezing Piping (0 to 39 degrees F (-18 to 4 degrees C):
   1. Application Requirements: Insulate the following sub-freezing HVAC piping systems:
      a. Refrigerant suction and liquid lines between evaporators and compressors.

B. Cold Piping (40 degrees F (4.4 degrees C) to ambient):
   1. Application Requirements: Insulate the following cold HVAC piping systems:
      a. HVAC chilled water supply and return piping.
      b. HVAC make-up water piping.

3.05 EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature):
   1. Application Requirements: Insulate the following cold equipment:
      a. Cold and chilled water pumps.
      b. Air separator.
      c. Miscellaneous cold components.

3.06 INSTALLATION OF PIPING INSULATION – INDOOR (EOC BUILDING)

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

F. Exposed covering shall be cleaned and sized for painting.

G. Pre-molded sectional covers shall be applied to flanges, fittings, and valves where possible. All other flanges, fittings, and valves shall be field-insulated and jacket applied manually. Insulation shall be the same thickness as that of the pipe insulation.

H. In general, pipe hangers will be sized to fit the pipe with insulation placed over the pipe hanger assembly. Insulation shall be grooved for hangers. The hanger area shall be completely filled with insulating material and sealed in vapor barrier areas.

I. Insulation, where terminated at equipment connections, ends of pipe, etc., shall be tapered at a 45-degree angle and sealed.

J. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

K. Butt pipe insulation against pipe hanger insulation inserts. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3-inch-wide vapor barrier tape or band.

3.10 INSTALLATION OF PIPING INSULATION - OUTDOOR (CHILLER/CONDENSER ENCLOSURES)

A. Application of the insulation shall be as specified above.

B. Metal jacketing shall be applied with laps positioned to shed water. All laps shall be a minimum of 2 inches. Aluminum jacketing shall be secured using bands and seals of similar materials. Band spacing shall be per jacketing manufacturer’s recommendations.

3.11 INSTALLATION OF VAPOR STOPS

A. In situations where the chilled water system is operational before the insulation system is completely installed, vapor stops must be installed at the end of each open section. Additionally vapor stops must be used at either

side of all penetration, insulation system interruptions, and at any cellular glass insulation to other insulation transition points.

B. Apply a one inch wide circumferential band of sealant to the inner bore of the cellular glass pipe insulation at each end of each half section to form the vapor stop. This will mate the inside of the pipe covering to the pipe and provide a vapor stop.

C. Apply cellular glass pipe insulation at the vapor stop to piping with all joints sealed a full depth with specified joint sealant. All joints shall be tightly sealed with no voids.

3.12 APPLICATION TO PIPE SUPPORTS

A. Install cellular glass insulation at pipe supports in accordance with the manufacturer's written instructions regarding the following.

1. Coating the inner and outer surfaces of the pipe insulation to be used ion the support area.

2. Selection of proper support configuration based on hanger spacing and load spreading plate thickness and length.

3.13 INSTALLATION OF EQUIPMENT INSULATION

A. Install equipment thermal insulation products in accordance with manufacturer's written instructions and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor barrier on equipment insulation as described above for piping and protect it to prevent puncture and other damage.

D. Apply insulation using staggered joint method for both single- and double-layer construction where feasible. Apply each layer of insulation separately.

E. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges, and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

F. Cover insulated surfaces with jacketing neatly fitted and firmly secured. Lap seams at least 2 inches. Apply over vapor barrier where applicable.

G. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, including metal vessel covers, fasteners, flanges, frames, and accessories.

H. Protect outdoor insulation from weather by installation of jacketing, as recommended by manufacturer.

3.14 REFRIGERANT PIPING SYSTEM INSULATION

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

3.15 EXISTING INSULATION REPAIR

A. Repair damaged sections of existing mechanical insulation, both previously damaged or damaged during this construction period. Replacement insulation shall be of same thickness as existing insulation. Jacket of replacement insulation shall overlap and seal to the existing insulation.

3.16 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Insulation Installer shall advise CONTRACTOR of required protection for insulation work during remainder of construction period to avoid damage and deterioration.

MECHANICAL INSULATION SCHEDULE

Application	Type	Temp. (°F)	Pipe Size Minimum Insulation Thickness Interior < 2"	Interior 2"-4"	Interior > 4"	Exterior (Chiller/Cond Enclosure) < 2"	Exterior (Chiller/Cond Enclosure) 2"-4"	Exterior (Chiller/Cond Enclosure) > 4"	Remarks
HVAC									
Chilled Water and make up water piping	Cellular Glass	40-55	1	1-1/2	1-1/2	1	1-1/2	1-1/2	
Refrigerant piping	Elastomeric Type	40	3/4	3/4	3/4	3/4	3/4	3/4	

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END OF SECTION

SECTION 15101 VALVES AND APPURTENANCES

PART 1 - GENERAL

1.01 SCOPE: The Work of this Section shall consist of furnishing all labor, material, and equipment necessary for the installation of the various valves in piping systems as shown on the Drawings and specified herein.

1.02 CONDITIONS OF THE CONTRACT APPLY:

1.03 GENERAL:

A. Like equipment specified herein shall be the end products of one manufacturer in order to achieve standardization for operation, maintenance, spare parts, and manufacturer's service.

B. See Conditions of the Contract and DIVISION 1, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

1.04 SUBMITTALS: Submittals shall be as specified in DIVISION 1, General Requirements. In addition, the following specific information shall be provided:

A. Valve Type Number.

1.05 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 GENERAL:

A. All valves shall be complete with all necessary operators, actuators, hand wheels, extension stems, worm and gear operators, operating nuts, wrenches, and other accessories or appurtenances which are required for the proper completion of the work.

B. Valves shall be suitable for the intended service. Renewable parts including discs, packing, and seats shall be of types recommended by valve manufacturer for intended service, but not of a lower quality than specified herein.

C. Valve and operators shall be suitable for the exposure they are subject to, interior or exterior, as applicable. They shall have all safety features required by OSHA.

D. Unless otherwise shown, valves shall be the same size as the adjoining pipe.

E. All units shall have the name of the manufacturer and the size of the valve cast on the body or bonnet or shown on a permanently attached plate in raised letters.

F. For the purpose of designating the type and grade of valve desired, a manufacturer's name and list or figure number is given in the following specifications. Valves of equal quality by other manufacturers will be considered in accordance with the General Conditions.

2.02 VALVE TYPES: The type of valve to be used for each service and application is shown on the Drawings.

2.03 VALVE OPERATORS:

A. General: All valves shall be equipped with operators. The valve operator types, as specified herein, describe only the general characteristics of the operator. The operator shall be compatible with the valve that it will be used with and shall be of the same manufacturer, or a product that is recommended by the valve manufacturer.

B. Manual Operators:

1. General:

a. Manual hand wheel operators shall be provided unless otherwise shown or specified. Ferrous hand wheels shall be galvanized and painted the same color as the valve and associated pipeline. Lever operators may be supplied on quarter-turn type valves 8 inches and smaller, if recommended by the manufacturer; however, operator force shall not exceed 40 pounds under any operating conditions, including initial breakaway.

b. When the maximum force required to operate a valve under full operating head exceeds 40 pounds, gear reduction operators shall be provided. Gear operators shall be totally enclosed and lubricated.

c. On quarter-turn valves, the valve operators shall be of the self-locking type to prevent the disc or ball from creeping and shall be provided with position indicators to show the position of the valve disc or ball. Operators of the worm and gear type shall have self-locking worm gears, one-piece design, of gear bronze material, accurately machine cut. The worm shall be hardened alloy steel, with thread ground and polished. Operators of the geared traveling nut type shall have threaded steel reach rods with an internally threaded bronze or ductile iron nut.

2. Exposed Operators:

a. Lever type operators shall have some means of being fixed in any given position to prevent accidental movement; shall be of rugged, noncorrosive construction; and shall be fully compatible with the valve.

2.04 VALVES:

A. Gate Valves:

1. Gate valves 2 inches and smaller shall be all-bronze with screwed bonnet and ends, single solid wedge gate, and rising stem. Valves shall be rated 125-pound SWP, 200-pound WOG, and shall be Stockham B105; Crane Co. Cat. No. 428; or equal.

B. Ball Valves (Screwed and Solder ends):

1. Brass or bronze body, screwed, blowout proof stem, Teflon seats and seals. Consolidated Brass “Apollo” Series 80, Crane 930-TF, Jamesbury 351, Jenkins 900T, Lunkenheimer, 780-HST, Powell 4120-T, Smith 140G, Whitey “60”Series.

2. Brass or bronze body, solder ends, blowout proof stem, Teflon seats and seals. Consolidated Brass “Apollo” Series 70, Jenkins 902T, Whitey “60”Series.

C. Butterfly Valves:

1. Butterfly valves shall be iron body, lug type, bronze disc, replaceable EPT seat, minimum 2-inch neck length to clear insulation. Gear operated for sizes 6 inches and larger. Centerline Series LT, Crane Series 44N-BXZ, Dmeco Series NE, Jenkins Series 232E Powell 3110-BA-1.

D. Check Valves:

1. Silent check valves shall be wafer style, iron body, bronze trim, center guided, with stainless steel springs. Valves shall be rated 150-pound WOG and shall be Mueller Steam Specialty 91AP, APCO Series 300, or equal.

PART 3 - EXECUTION

3.01 GENERAL:

A. Boltholes of flanged valves shall straddle the vertical centerline of the pipe run. Prior to installing flanged valves, the flange faces shall be thoroughly cleaned. After cleaning, insert gasket and bolts, and tighten the nuts progressively and uniformly. If flanges leak under pressure, loosen or remove the nuts and bolts, and retest the joints. Joints shall be watertight at pressures before acceptance.

B. Thoroughly clean threads of screwed joints by wire brushing, swabbing, or other approved methods. Apply approved joint compound to threads prior to making joints. Joints shall be watertight at test pressures before acceptance.

3.02 PLACING: Generally, unless otherwise indicated on the Drawings, all valves installed in horizontal runs of pipe having centerline elevations 4 feet-6 inches or less above the finish floor shall be installed with their operating stems vertical. Valves installed in horizontal runs of pipe having centerline elevations between 4 feet-6 inches and higher above the finish floor shall be installed with their operating stems horizontal. If adjacent piping prohibits this, the stems and operating handwheel shall be installed above the valve centerline as close to horizontal as possible. Valves installed in vertical runs of pipe shall have their operating stems oriented to facilitate the most practicable operation.

3.03 TESTING:

A. Valves shall be tested at the same time that the adjacent pipeline is tested. Joints shall show no visible leakage under test. Repair joints that show signs of leakage prior to final acceptance. If there are any special parts of control systems or operators that might be damaged by the pipeline test, they shall be properly protected. The CONTRACTOR will be held responsible for any damage caused by the testing.

B. If requested by the DISTRICT, the valve manufacturer shall furnish an affidavit stating the materials options furnished and/or that he has complied with these and other referenced specifications.

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END OF SECTION

SECTION 15121 BACKFLOW PREVENTERS

PART 1 - GENERAL

1.01 SCOPE: The Work covered by this Section consists of furnishing and installing backflow prevention devices as shown on the Drawings and as specified herein.

1.02 STANDARD REFERENCES: The following standard specifications shall apply to the work of this section:

A. American Water Works Association (AWWA):

1. C-506 - Standard for Backflow Prevention Devices, Reduced Pressure Principle and Double Check Valve types.

1.03 SUBMITTALS:

A. Submit as specified in DIVISION 1.

B. The Contractor shall submit the following:

1. Manufacturer's product data for each type of product included in this section.

1.04 QUALITY ASSURANCE: Each backflow prevention device shall be installed by a certified technician as described in PBCWUD's Cross Connection Control Manual.

1.05 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS: Subject to compliance with requirements, provide products of one of the following:

MANUFACTURER	MODEL NO.	SIZE
Wilkens (Neptune)	575	3/4" to 6"
Hersey (BEECO)	FRP II	3/4" to 2"
Watts	909-QT	3/4" to 2"
Febco	825-Y-RW	3/4" to 2"

2.02 BACKFLOW PREVENTERS:

A. The Contractor shall provide backflow preventers that comply with requirements of governing authorities, for locations indicated.

B. The backflow preventers provided shall be of the reduced pressure principle type. Parts and materials shall be as shown on the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. The Contractor shall install items included in this section at the locations indicated on the Drawings.

B. Backflow preventers shall be installed by a certified Backflow Prevention Device Technician in accordance with PBCWUD rules.

C. The Contractor shall be responsible for all required checkout and testing of the items and/or systems provided and installed under this section. Fittings, fasteners, other items, etc., shall be furnished and installed as required to make complete and workable installations at no additional cost to the District.

END OF SECTION

SECTION 15130 PUMPS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following types of HVAC pumps:

1. Base-mounted pump.

B. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1, including Section 01600, apply to Work of this Section.

1.02 DESIGN REQUIREMENTS

A. Pumps shall be selected so operating point is not more than 5 percent under maximum efficiency of impeller. Maximum efficiency of impeller shall be midway plus or minus 1/4 of published pump curve. The ratio of the maximum pump impeller diameter to the selected pump impeller diameter shall be 1.15 or greater. Motors shall be non-overloading at any point on the pump curve.

B. The pump and motor combination shall be designed for outdoor service in an unprotected environment. The pumps/motors will be subjected to rain and wind.

1.03 SYSTEM RESPONSIBILITY

A. Pump manufacturer may rely upon information on Pump Schedule pertaining to steady-state operating conditions, however, pump manufacturer shall be responsible to review this Specification Section, Section 01600, relevant pipe Drawings, schematics, and electrical and instrumentation Drawings to ensure that equipment offered is suitable for the purposes intended by the Contract Documents. Refer questions and clarifications to ENGINEER.

1.04 SUBMITTALS

A. Shop Drawings: Submit in accordance with requirements of Section 01300, Shop Drawings covering the items included under this Section. Shop Drawing submittals shall include:

1. Shop Drawings showing layout and connections for pumps. Include setting Drawings with templates, and directions for installation of foundation bolts, anchor bolts, and other anchorages.
2. Product data including certified performance curves, weights (shipping, installed, and operating), furnished specialties, and accessories, plus installation and start-up instructions.
3. CONTRACTOR shall submit to ENGINEER for approval performance curves on each pump. These curves shall include capacity, head, required NPSH efficiency and horsepower required for operation as shown on Pump Schedule and on Drawings.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01730, operation and maintenance manuals for items included under this Section.

1.05 QUALITY ASSURANCE

A. Codes and Standards:

1. Hydraulic Institute Compliance: Design, manufacture, and install pumps in accordance with "Hydraulic Institute Standards."
2. National Electrical Code Compliance: Components shall comply with NFPA 70, "National Electrical Code."

3. UL Compliance: Pumps shall be listed and labeled by UL and comply with UL Standard 778, "Motor Operated Water Pumps."
4. NEMA Compliance: Electric motors and components shall be listed and labeled NEMA. All motors shall be NEMA premium rated.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Apply factory finish paint to assembled, tested units prior to shipping.

B. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anti-corrosion compound. Protect flanges, pipe openings, and nozzles.
1. Store pumps in a dry location.
2. Retain shipping flange protective covers and protective coatings during storage.
3. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

C. Comply with manufacturer's rigging instructions for handling, if required.

1.07 WARRANTY

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. Base-Mounted Pump:
   a. Bell & Gossett.
   b. Aurora.
   c. Taco.

2.02 BASE-MOUNTED PUMP

A. Pumps shall be centrifugal end suction type. Pumps shall be motor driven through a flexible coupling, mounted on a common base. Pumps shall be bronze fitted.

B. Casing: Pump casing shall be cast iron suitable for 175 psi working pressure and have replaceable bronze wearing rings. Supply casings with plugged vent, drain, and gauge tappings.

C. Impeller: Provide enclosed type, bronze impeller which has been hydraulically and dynamically balanced and keyed to the shaft.

D. Seal: The pumps shall be furnished with mechanical seals with carbon seal ring and ceramic seat, designed for 225 degrees F continuous service. Provide pump with drain pan and tapping for drain connection.

E. Shaft and Sleeve: Provide shafts of stainless steel with stainless steel sleeve. The first critical speed of the rotor shall be 5,600 rpm or above.

F. Pump Bearings: The bearing assembly shall be fitted with oil- or grease-lubricated ball bearings.

G. Shaft Coupling: Pump shall be coupled to motor through a flexible coupling (1.15 safety factor) in such manner that the pump may be completely serviced without disconnecting piping and without disturbing pump or motor mounts. Coupler shall be covered with a removable metal coupler guard.

H. Mounting Frame: Pumps are to be mounted on a rigid steel or cast iron sub base suitable for grouting.

I. Motor: Provide totally enclosed, fan cooled, premium efficiency motors. Motors shall be premium efficiency based on IEEE-112 Method B per NEMA Standard MG1. Motors shall have Class F insulation and be suitable for continuous VFD use for variable torque loads. Motor nameplates shall be marked "For VFD Control".All motors shall be NEMA premium rated.

PART 3 - EXECUTION

3.01 EXAMINATION

A. The following requirements apply to pumps furnished under this Section.

1. Examine areas, equipment foundations, and conditions for compliance with requirements for installation and other conditions affecting performance of plumbing pumps. Do not proceed with installation until unsatisfactory conditions have been corrected.

2. Examine rough-in for piping systems to verify actual locations of piping connections prior to installation.

3.02 EQUIPMENT BASES

A. Install frame-mounted pumps on 4-inch-high reinforced pad 4 inches larger on each side than the pump base.

3.03 INSTALLATION

A. Comply with manufacturer's written installation and alignment instructions.

B. Install pumps in locations and arrange to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that the weight of the piping system does not rest on the pump.

D. Support pump base plate on rectangular metal blocks and shims, or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting.

E. Adjust the metal supports or wedges until the pump and driver are level. Check the suction and discharge flanges of the pump to verify that they are level and plumb.

F. After pumps are level, tighten the foundation bolts evenly but not too firmly.

3.04 CONNECTIONS

A. Install valves that are same size as the piping connecting the pump.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

C. Install a triple duty valve and butterfly valve on the discharge side of pumps.

D. Install a pump suction diffuser and gate valve on the suction side of base-mounted pumps.

E. Install flexible connectors on the suction and discharge side of each base-mounted pump. Install flexible connectors between the pump casing and the discharge valves and upstream from the pump suction diffuser.

F. Install a pressure gauge at the suction and discharge of each pump at the integral pressure gauge tappings provided.

G. Electrical and Control wiring and connections are specified in Division 16 Sections.

3.05 FIELD QUALITY CONTROL

A. Check suction line connections for tightness to avoid drawing air into the pump.

B. A factory-trained representative shall be furnished to check the installation of the water pump, start the pump system, and instruct personnel on its operation.

3.06 COMMISSIONING

A. Final Checks Before Start-up: Perform the following preventative maintenance operations and checks before start-up:

1. Lubricate oil-lubricated bearings.

2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with manufacturer's recommendations.

3. Check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.

4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.

B. Starting Procedure for pumps with shutoff power not exceeding the safe motor power:

1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.

2. Open the discharge valve slowly.

3. Check the general mechanical operation of the pump and motor.

4. If the pump is to be started against a closed check valve with the discharge valve open, the steps are the same except that the discharge gate valve is opened some time before the motor is started.

END OF SECTION

SECTION 15183 - HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Piping systems for chilled water cooling and make-up water for this system. Piping materials and equipment specified in this Section include:
   1. Materials - pipe and valves.
   2. Special duty valves.
   3. Hydronic specialties.

B. Related Documents: Drawing and general provisions of Contract, including General and Supplementary Conditions and Division 1, apply to Work of this Section.

1.02 DEFINITIONS

A. Pipe sizes used in this Specification are nominal pipe size (NPS).

1.03 SYSTEM DESCRIPTION

A. The hydronic piping systems are the "water-side" of air conditioning system. Hydronic piping systems specified in this Section include:
   1. Chilled water piping systems.

1.04 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01300, Submittals covering the items included under this Section. Shop Drawing submittals shall include:
   1. Product data, including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.
   2. Furnish flow and pressure drop curves or data for diverting fittings, automatic flow control valves, and calibrated plug valves based on manufacturer's testing.
   3. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.
   4. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe, fittings, and specialties.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01730, operation and maintenance manuals for items included under this Section.

C. Test and Inspection Report: Submit a written report to ENGINEER documenting testing and/or inspection results. The report shall be prepared as noted under Section 01410.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following:
   1. ASME B 31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
   2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
   3. ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualification," for qualifications for welding processes and operators.

4. Florida Building Code - Mechanical.

1.06 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate the installation of pipe sleeves or cored holes in existing walls for wall penetrations.

1.07 EXTRA STOCK

A. Maintenance Stock: Furnish a sufficient quantity of chemical for initial system start-up and for preventative maintenance for 1 year from Substantial Completion.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:
   1. Pump Discharge Valves:
      a. Amtrol, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett ITT, Fluid Handling Division.
      d. Taco, Inc.
   2. Pressure Reducing Valves:
      a. Amtrol, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett ITT, Fluid Handling Division.
      d. Taco, Inc.
   3. Safety Relief Valves:
      a. Bell & Gossett ITT, Fluid Handling Division.
      b. Dunham-Bush.
   4. Air Vents
      a. Armstrong Machine Works.
      b. Bell & Gossett ITT, Fluid Handling Division.
      c. Hoffman Specialty ITT, Fluid Handling Division.
   5. Diaphragm Compression Tanks:
      a. Amtrol, Inc.
      b. Wessels.
      c. Bell & Gossett ITT, Fluid Handling Division.
   6. Air Separators:
      a. Amtrol, Inc.
      b. Bell & Gossett ITT, Fluid Handling Division.
      c. Taco, Inc.
   7. Pump Suction Diffusers:
      a. Amtrol, Inc.
      b. Bell & Gossett ITT, Fluid Handling Division.
      c. Taco, Inc.
   8. Chemical Feeder (Shot Feeder):
      a. Burmah Technical Services.
      b. Culligan USA.
      c. Vulcan Laboratories, Subsidiary of Clow Corp.
      d. York-Shipley, Inc.
   9. Y-Pattern Strainers:

a. Armstrong Machine Works.
b. Hoffman Specialty ITT, Fluid Handling Division.
c. Spirax Sarco.
d. Victaulic Co. of America.
e. Watts Regulator Co.

2.02 MATERIALS - PIPE AND VALVES

A. Pipe materials shall comply with Section 15251 “piping for Heating and Air Conditioning Systems”.

B. Pipe construction shall comply with Section 15010 “Piping”.

C. Pipe supports and penetrations shall comply with section 15020 “Pipe Supports and Penetrations”.

D. Valves and appurtenances shall comply with Section 15101 “Valves and Appurtenances”.

2.03 SPECIAL DUTY VALVES

A. Pump Discharge Valves: Features shall include non-slam check valve with spring-loaded weighted disc, calibrated adjustment feature to permit regulation of pump discharge flow and shutoff, 175 psig working pressure, 300 degrees F maximum operating temperature, cast iron body, bronze disc and seat, stainless steel stem and spring, and Teflon packing. Valves shall have flanged or grooved ends to match piping system. Provide straight or angle pattern as indicated.

B. Pressure-Reducing Valves: Diaphragm operated cast iron or brass body valve with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have the capability for field adjustment.

C. Safety Relief Valves: 125 psig working pressure and 250 degrees F maximum operating temperature, designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast iron with all wetted internal working parts made of brass and rubber. Select valve to suit actual system pressure and Btu capacity.

D. Combined Pressure/Temperature Relief Valves: Diaphragm-operated, cast iron or brass body valve with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment. Safety relief valve designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast iron with all wetted internal working parts made of brass and rubber, 125 psig working pressure and 250 degrees F maximum operating temperature. Select valve to suit actual system pressure and Btu capacity. Provide with fast fill feature for filling hydronic system.

E. Drain Valves: Minimum of 3/4-inch hose bibb with threaded hose connection. Provide with hose cap.

2.04 HYDRONIC SPECIALTIES

A. Air Vent:
1. Manual: Minimum of 3/8-inch pipe stub with ball valve.
2. Automatic: High capacity air vents with cast iron body and stainless steel, brass, and EPDM internals. Operating pressures up to 150 psig and temperatures up to 250 degrees F. Inlet of 3/4-inch minimum and discharge of 3/8-inch minimum.

B. Diaphragm Compression Tanks: Tank shall be pre-charged diaphragm type with diaphragm made of heavy-duty butyl rubber. Tank shall be pre-charged to 12 psi and be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. Tank pressure shall be field adjustable.

C. Air Separator: Welded black steel, ASME constructed and labeled for minimum 125 psig water working pressure and 375 degrees F operating temperature. Perforated stainless steel air collector tube designed to direct released air into compression tank, tangential inlet and outlet connections, screwed connections up to and including 2-inch NPS, flanged connections for 2-1/2-inch NPS and above, threaded blowdown connection sized as indicated for full system flow capacity.

D. Pump Suction Diffusers: Cast iron body with threaded connections for 2-inch and smaller, flanged connections for 2-1/2-inch and larger, or grooved ends to match piping system; 175 psig working pressure, 300 degrees F maximum operating temperature; and complete with the following features:
   1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
   2. Cylinder strainer with 3/16-inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
   3. Disposable fine mesh strainer to fit over cylinder strainer.
   4. Permanent magnet located in flow stream, removable for cleaning.
   5. Adjustable foot support designed to carry weight of suction piping.
   6. Blowdown tapping in bottom; gauge tapping in side.

E. Y-Pattern Strainers: 125 psig working pressure, cast iron body (ASTM A 126, Class B) or ductile iron body (ASTM A 536), grooved coupling ends or flanged ends for 2-1/2-inch and larger and threaded connections for 2-inch and smaller, bolted cover, perforated Type 304 stainless steel basket, and bottom drain connection.

F. Chemical Feeder: Bypass type chemical feeders of 1.5-gallon capacity, cast iron construction; 125 psig working pressure; complete with fill funnel and inlet, outlet, and drain valves.
   1. Chemicals shall be specially formulated to prevent accumulation of scale and corrosion in piping system and connected equipment, developed based on a water analysis of make-up water.

PART 3 - EXECUTION

3.01 PIPING INSTALLATIONS

A. Install piping at a uniform grade of 1 inch in 40 feet upward in the direction of flow.

B. Pipe Expansion: The installation of all pipes shall be such as to allow for expansion using offsets, swing joints, expansion joints, etc., as shown or as may be necessary to prevent undue strain on piping.

C. All piping shall be installed in such a way that it will be free to expand and contract without noise or damage to itself or to the building.

3.02 HANGERS AND SUPPORTS

A. Pipe supports and penetrations are specified in Section 15020 “Pipe Supports and Penetrations. Conform to the table below for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs. Size clevis to fit over the insulation, and provide insulation shields to allow for expansion and contraction of piping. See insulation specification for insulation shield details.
   2. Adjustable roller hangers and spring hangers for individual horizontal runs.
   3. Pipe roller complete, MSS Type 44 for multiple horizontal runs supported on a trapeze.
   4. Spring hangers to support vertical runs (where required).

C. Install hangers with the following minimum rod sizes and maximum spacing:

Nominal Pipe Size	Max. Span Feet	Min. Rod Size Inches
1	7	3/8
1-1/2	9	3/8
2	10	3/8
3	12	1/2
3-1/2	13	1/2
4	14	5/8
5	16	5/8
6	17	3/4

D. Support vertical runs at each floor.

3.03 PIPE JOINT CONSTRUCTION

A. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe fittings and valves as follows:
   1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
   2. Align threads at point of assembly.
   3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
   4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.
      a. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Welded Joints: Comply with the requirement in ASME Code B31.9, "Building Services Piping."

D. Flanged Joints: Align flange surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

3.04 VALVE APPLICATIONS

A. General-duty Valve Applications: Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
   1. Shutoff Duty: Use butterfly, ball, and gate valves
   2. Throttling Duty: Use globe and butterfly valves
   3. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.
   4. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

B. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

C. Install check valves on each pump discharge and elsewhere as required to control flow direction.

D. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.

E. Install safety relief valves as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves as required to regulate system pressure.

3.05 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in the system, and elsewhere as required for system air venting.

B. Install in-line air separators in pump suction lines. Run piping to compression tank with 1/4 inch per foot (2 percent) upward slope towards tank. Install drain valve on units 2-inch and larger.

C. Install pump suction diffusers on pump suction inlet; adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.

D. Install pump discharge valves in horizontal or vertical position with stem in upward position. Allow clearance above stem for check mechanism removal.

E. Install shot-type chemical feeders in each hydronic system where indicated in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line off main using globe valves on each side of feeder, and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

F. Install compression tanks in accordance with the manufacturer's recommendations where shown on the drawings. Install gauge glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

3.06 FIELD QUALITY CONTROL

A. Preparation for Testing: Prepare hydronic piping in accordance with ASME B 31.9, and as follows:
   1. Leave joints including welds uninsulated and exposed for examination during the test.
   2. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
   3. Flush system with clear water. Clean strainers.
   4. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
   5. Install relief valve set at a pressure no more than 1/3 higher than the test pressure to protect against damage by expansion of liquid or other source of overpressure during the test.

B. Test Hydronic Piping as follows:
   1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
   2. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of that liquid.
   3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low-pressure filling lines are disconnected.
   4. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure

at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code for Pressure Piping, Building Services Piping.

5. After the hydrostatic test pressure has been applied for at least ten minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

3.07 ADJUSTING AND CLEANING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

B. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

C. Chemical Treatment: Provide the services of a chemical treatment supplier to prepare a water analysis to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.08 COMMISSIONING

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:
   1. Remove and clean strainers.
   2. Check pump for proper direction of correct improper wiring.
   3. Set automatic fill valves for required system pressure.
   4. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
   5. Set temperature controls so all coils are calling for full flow.
   6. Check operation of automatic bypass valves.
   7. Check and set operating temperatures of chiller to design requirements.
   8. Lubricate motors and bearings.

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END OF SECTION

SECTION 15185 - REFRIGERANT PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Refrigerant piping used for air conditioning applications, including:
   1. Pipes, tubing, fittings, and specialties.
   2. Special-duty valves.
   3. Refrigerants.

B. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1, including Section 01600, apply to Work of this Section.

C. Products Installed but not Furnished under This Section include: Refrigerant specialties and refrigerant accessories furnished as an integral part of or separately with the condensing units installed under this contract.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01300, Submittals covering the items included under this Section. Shop Drawing submittals shall include:
   1. Shop Drawings showing layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and proximate to equipment. Refrigerant piping shall be sized in accordance with the manufacturer's recommendations for this application of installing new condensers to support existing Computer Room Air Conditioning (CRAC) units. Manufacturer to provide for sizing of new piping and verification of size of existing piping.
   2. Product data for items included under this Section, including:
      a. Each type valve specified.
      b. Each type refrigerant piping specialty specified.
   3. Brazer's certificates signed by CONTRACTOR certifying that brazers comply with requirements specified under Quality Assurance below.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01730, operation and maintenance manuals for items included under this Section.

1.03 QUALITY ASSURANCE

A. Qualify brazing processes and brazing operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

B. Regulatory Requirements: Comply with provisions of the following codes:
   1. ANSI B31.5, ASME Code for Pressure Piping - Refrigerant Piping.
   2. ANSI/ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.
   3. Florida Building Code - Mechanical

1.04 SEQUENCING AND SCHEDULING

A. Coordinate the installation PVC floor conduit modifications and wall penetrations in the Chiller enclosure.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:
   1. Refrigerant Valves and Specialties:
      a. Alco Controls Division, Emerson Electric.
      b. Danfoss Electronics, Inc.
      c. EATON Corporation, Control Division.
      d. Henry Valve Company.
      e. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.
      f. Sporlan Valve Company.

2.02 PIPE MATERIALS

A. Materials shall conform to the Specification Section 15251, ”Piping for Heating and Air Conditioning Systems”.

2.03 VALVES

A. Complete valve assembly shall be UL listed and designed to conform to ARI 760.

B. Charging and Purging Valve, 3/8 to 5/8 inch: Forged brass, backed, non-backseating, bottom solder connection, side flare connection, seal caps, 300 degrees F maximum temperature, 500 psi maximum working pressure.

2.04 REFRIGERANT PIPING SPECIALTIES

A. Complete refrigerant piping specialty assembly shall be UL listed and designed to conform to ARI 760.

B. Strainers: 500 psig maximum working pressure; forged brass body with monel 80-mesh screen, and screwed cleanout plug, Y-pattern with solder-end connections.

C. Moisture/Liquid Indicators: 500 psig maximum operation pressure, 200 degrees F maximum operating temperature, forged brass body with replaceable polished optical viewing window, and solder-end connections.

D. Filter Dryers: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder-end connections. Furnish complete with replaceable filter drier core kit including gaskets and standard capacity desiccant sieves to provide micronic filtration.

E. Suction Line Filter Dryer: 350 psig maximum operation pressure, 225 degrees F maximum operating temperature, steel shell and wrought copper fittings for solder-end connections. Permanent filter element shall be molded felt core surrounded by a desiccant for removal of acids and moisture for refrigerant vapor.

F. Suction Line Filters: 500 psig maximum operation pressure, steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder-end connections. Furnish complete with replaceable filter core kit, including gaskets.

G. Flanged Unions: 400 psig maximum working pressure, 330 degrees F maximum operating temperature, 2 brass tail-piece adapters for solder-end connections to copper tubing, flanges for 7/8 inch through 1-5/8-inch unions shall be forged steel, and for 2-1/8-inch through 3-1/8-inch shall be ductile iron, 4 plated steel bolts with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory applied rust-resistant coating.

2.05 REFRIGERANT

A. Refrigerant No. 22, in accordance with ASHRAE Standard 34. CONTRACTOR to verify refrigerant type with Liebert Corp for compatibility with existing CRAC units and new condensers.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.02 PIPE APPLICATIONS

A. If other than Type ACR tubing is used, clean and protect inside of tubing as specified in Article "Cleaning" below.

3.03 PIPING INSTALLATION

A. Install refrigerant piping in accordance with ASHRAE Standard 15, "The Safety Code for Mechanical Refrigeration."

B. Install piping in as short and direct arrangement as possible to minimize pressure drop.

C. Install piping for minimum number of joints using as few elbows and other fittings as possible.

D. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

E. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

F. Insulate Suction Lines. Liquid lines are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.
   1. Do not install insulation until system testing has been completed and all leaks have been eliminated.

G. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

H. Install copper tubing in protective covers as shown on the drawings in locations where copper tubing will be exposed to mechanical injury such as walkways in the chiller/condenser enclosure walkways.

I. Slope Refrigerant Piping as follows:
   1. Install horizontal hot gas discharge piping with 1/2 inch per 10 feet downward slope away from the compressor.
   2. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
   3. Install traps and double risers where indicated and where required to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

J. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

K. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

L. Install unions to allow removal of solenoid valves, pressure-regulating valves, expansion valves, and at connections to compressors and evaporators.

3.04 HANGERS AND SUPPORTS

A. Install refrigerant pipe supports similar to the existing supports. Materials shall be galvanized steel or stainless steel and isolated from the copper piping with suitable copper or non-metallic materials.

3.05 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."
   1. CAUTION: When solenoid valves are being installed, remove the coil to prevent damage. When sight glasses are being installed, remove the glass. Remove stems, seats and packing of valves, and accessible internal parts of refrigerant specialties before brazing. Do not apply heat near the bulb of the expansion valve.

B. Fill the pipe and fittings during brazing, with an inert gas (i.e., nitrogen or carbon dioxide) to prevent formation of scale.

3.06 VALVE INSTALLATIONS

A. Install refrigerant valves where indicated and in accordance with manufacturer's instructions.

B. Install globe valves on each side of strainers and dryers, in liquid and suction lines at evaporators, and elsewhere as indicated or required.

C. Install a full sized, 3-valve bypass around each drier.

D. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

3.07 EQUIPMENT CONNECTIONS

A. Install piping adjacent to machine to allow servicing and maintenance.

3.08 FIELD QUALITY CONTROL

A. Inspect, test, and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI.

B. Repair leaking joints using new materials, and retest for leaks.

3.09 CLEANING

A. Before installation of copper tubing other than Type ACR tubing, clean the tubing and fitting using following cleaning procedure:
   1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.
   2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.10 ADJUSTING AND CLEANING

A. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.11 COMMISSIONING

A. Charge System using the following procedure:
   1. Install core in filter dryer after leak test but before evacuation.
   2. Evacuate refrigerant system with vacuum pump until temperature of 35 degrees F is indicated on vacuum dehydration indicator.
   3. During excavation, apply heat to pockets, elbows, and low spots in piping.
   4. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
   5. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.
   6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Train OWNER's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.

C. Review data in Operating and Maintenance Manuals. Refer to Section 01600.

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END OF SECTION

SECTION 15251 PIPING FOR HEATING AND AIR CONDITIONING SYSTEMS

PART 1 - GENERAL

1.01 SCOPE: The Work of this Section shall consist of furnishing all labor, materials, and equipment necessary for installation of piping for heating and air conditioning systems as shown on the Drawings and specified herein.

1.02 CONDITIONS OF THE CONTRACT APPLY:

1.03 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER'S standard warranty, but for no less than one year from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS: (See schedule on page 15251-3)

A. All pipe and fittings shall be of domestic manufacture.

SERVICE	PIPE MATERIAL TYPE
Chilled Water	1 & 5 – See Drawings for limits
Refrigerant Piping	6
Cold Water Make-Up	5
Chemical Feed for Hot & Chilled Water System	1
Miscellaneous Drains (not listed above)	1
Water treatment piping and underground conduit.	7

2.02 COPPER PIPE JOINTS:

A. Joints in copper tubing for water service shall be made with a non-corrosive paste flux and solid string solder composed of 95 percent tin and 5 percent antimony. 50-50 solder will not be permitted.

B. Joints in copper tubing for refrigerant piping shall be silver brazed with silver solder having a melting point in excess of 1000 degrees Fahrenheit.

2.03 PVC JOINTS:

A. Joints in PVC piping installed in the chiller and condenser enclosures for the water treatment system piping and the PVC conduit for the underground refrigerant piping shall be made with solvent cement. Provide flanged connections to all valves.

PIPE AND FITTINGS SCHEDULE

TYPE	PIPE SIZES	PIPE MATERIAL	STANDARD	FITTING MATERIAL	STANDARD
1	2" and Smaller	Sch. 40 Black Steel, Butt Welded	ASTM A53 TYPE F	150 lb. Black Malleable Iron, Screwed	ASME/ANSI B16.3
1	2-1/2" thru 10" Incl.	Sch. 40 Black Steel, Butt Welded	ASTM A53 TYPE E	Standard Weight Butt Welding Type	ASME/ANSI B16.9, ASTM A234
5	All Sizes	Type "L" Hard-Drawn Copper	ASTM B88-76	Wrought Copper Solder Joint	ASME/ANSI B16.22-73
6	All Sizes	Type "K" Hard-Drawn Copper	ASTM B88-76	Wrought Copper Silver Brazed Joint	ASME/ANSI B16.22-73
7	All Sizes	Sch. 40 PVC	ASTM D1785	Sch. 40 Socket and Flanged	ASTM D1785

2.04 FLANGES AND UNIONS:

A. Union joints in pipe 2 inches and smaller and flange joints in pipe 2-1/2 inches and larger shall be provided in each pipe line preceding the connection to each piece of equipment. Unions and flanges shall be black or galvanized to match the piping system in which installed.

B. Flanges shall be faced true and provided with 1/16-inch ring type asbestos gasket conforming to ANSI Standard B16.21-1962. Flanges shall have a raised or flat face to mate with adjacent flanges or valves, fittings and equipment.

1. Flanges in threaded pipe lines shall be 125 lb. cast-iron screwed flanges conforming to Federal Specification WW-F-406C.

2. Flanges in welded pipe lines shall be 150-lb. steel slip-on type welding flanges conforming to ASTM A181-68 and dimensions in accordance with ANSI Standard B16.5-1973.

3. Flange bolts shall be carbon steel, all threaded type, and nuts shall be carbon steel hexagon type. Steel for bolts and nuts shall conform to ASTM A307-74, Grade A for use with steel flanges and Grade B for use with cast-iron flanges.

C. Unions shall be 150-lb. malleable iron type, screwed, conforming to Federal Specification WW-U-531C.

1. Unions provided between copper and ferrous pipe connections shall be the insulated type to separate dissimilar metal connections in piping systems and prevent galvanic corrosion. Refer to SECTION 15120 Miscellaneous Piping Specialties.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Pipes shall have burrs removed by reaming.

B. Changes in direction of piping shall be made with fittings.

C. Changes in pipe sizes in horizontal lines shall be made with eccentric reducing couplings, except reducing tees and reducing elbows will be allowed for connections for pressure gauges and gauge cocks, for thermometers and test wells, and for pipe mounted insertion-type temperature control devices. In chilled water lines eccentric reducing couplings shall be installed with the flat side on top to maintain the top of the pipe line flush.. Reducing tees, reducing elbows and concentric reducing couplings will be allowed for changing pipe sizes in vertical risers and for making connections to

equipment from vertical risers except in pump suction lines eccentric reducing couplings only will be allowed.

3.02 QUALIFICATIONS OF WELDERS:

A. All Welders employed for the work shall be qualified under the requirements of American National Standards for Institute Specification B31.1.0, Section 127.5.

B. Evidence of welders' qualifications shall be submitted to the DISTRICT before any welds are made.

3.03 PIPE JOINTS:

A. Screw Joints for Steel Pipe: After cutting and before threading, pipe shall be reamed and shall have burrs removed. Screw joints shall be made with tapped threads. Screw joints shall be made with graphite and oil applied to male threads only. Caulking of threaded joints to stop or prevent leaks will not be permitted.

B. Welded joints shall be fusion-welded. Changes in direction of piping shall be made with welding fittings only. Mitering of notching pipe to form elbows and tees will not be permitted. Branch take-offs at 90 degrees from mains shall be made with welded tee fittings, except where main size is larger than 2 inches. Factory fabricated forged steel shaped fittings may be used in lieu of welding tees if the main is two pipe sizes or more larger than the branch takeoff; shaped fittings shall be weldolets for branch sizes 2-1/2 inches and larger and threadolets for branch sizes 2 inches and smaller; branch takeoffs at 45 degrees to mains shall be made with factory fabricated latrolets.

1. Defective Welding: Defective welds shall be removed and replaced at no additional cost to the DISTRICT. Repairing of defective welds by adding new material over the defects or by peening will not be permitted.

C. Copper tubing shall be cut square and burrs shall be removed. Both inside and outside of tubing shall be cleaned with emery cloth before joining.

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END OF SECTION

SECTION 15670 - CONDENSING UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Air-cooled condensing units.

B. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1, including Section 01600, apply to Work of this Section.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01300, Submittals covering the items included under this Section. Shop Drawing submittals shall include:
   1. Submit manufacturer's technical product data/Shop Drawings, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), dimensions, required clearances, and methods of assembly of components, furnished specialties and accessories; and installation and start-up instructions.
   2. Wiring Diagrams: Submit ladder-type wiring diagrams for power and control wiring required for final installation of condensing units and controls. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01730, operation and maintenance manuals for items included under this Section.

1.03 QUALITY ASSURANCE

A. Codes and Standards:
   1. Capacity ratings for condensing units 135,000 Btuh or greater shall be in accordance with (ARI) Standard 360, "Standard for Commercial and Industrial Unitary Air Conditioning Equipment." Refrigeration system of condensing units shall be constructed in accordance with ASHRAE Standard ASHRAE 15, "Safety Code for Mechanical Refrigeration."
   2. Condensing units shall be listed by UL and have UL label affixed.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Handle condensing units and components carefully to prevent damage. Follow manufacturer's written instructions for rigging. Replace damaged condensing units or components.

B. Store condensing units and components in clean dry place off the ground. Protect from weather, water, and physical damage.

1.05 WARRANTY

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER’S standard warranty, but for no less than five years from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, the new condensing units shall be the product of the Liebert Company and be matched to the new Computer Room Air Conditioning Units (CRAC) specified in Section 15731 to provide air conditioning performance at the CRAC Units as specified. No substitution is permitted.

2.02 AIR-COOLED CONDENSING UNITS

A. Factory assembled and tested air-cooled condensing units consisting of casing, compressors, condensers, coils, condenser fans and motors, and unit controls. Capacities and electrical characteristics are scheduled on Drawings. Capacities listed are nominal capacities and the manufacturer shall make the final selection of the condensing units and capacities to support the capacities of the new CRAC units served considering the installation, location of condensing units and configuration of refrigerant piping system. The refrigerant shall be R-407C.

B. Unit Casings: Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to controls, condenser fans, motors, and drives.

C. Controls: Operating and safety controls shall include condenser fan motors with thermal and overload cutouts. Control transformer, if required, shall be 115 volts. Provide magnetic contactors for condenser fan motors. Additional features include:

1. A locking disconnect switch, factory mounted and wired, for single external electrical power connection.
2. An indoor unit interlock circuit shall enable condenser operation whenever indoor unit compressors are active.
3. Only supply wiring and indoor unit interlock wiring are required at condenser installation.

D. Condenser coil: Condenser coil shall be constructed of copper tubes in a staggered tube pattern. Tubes shall be expanded in continuous, corrugated aluminum fins. The fins shall have full depth fin collars completely covering the copper tubers which shall be connected to heavy wall Type L headers. Inlet coil connector tubes shall pass through relieved holes in the tube sheet for maximum resistance to piping strain and vibration. The hot gas and liquid lines shall be spun shut and shall include factory installed Schrader valve. Coils shall be factory leak tested at a minimum of 300 psig, dehydrated, then filled and sealed with a nitrogen holding charge for shipment. Field relief of the Schrader valve shall indicate a leak free system. The condenser coil shall have a factory dipped phenolic (Heresite) corrosion resistant coil coating applied. Coating shall be in accordance with the condenser manufacturer's recommendations and applied by fully submerging the condenser coil in the coating material in accordance with the coating material manufacturer's recommendations to ensure all surfaces receive the coating. The number of coats applied shall be in accordance with the coating manufacturer's recommendations and procedures. The finished coated coil shall meet the performance requirements of the unit and fin spacing and coil size shall be selected to accommodate the use of the selected coating. The coating shall be applied during the or after manufacturer of the coil, but prior to delivery the jobsite. Jobsite application of the corrosion coating is unacceptable.

E. Condenser Fans and Motors: Propeller type condenser fans for vertical air discharge direct drive. Additional features include:
1. Fan motors shall be continuous air over design and shall be equipped with rain shield and permanently sealed bearings. Motors shall be rigidly mounted on die-formed galvanized steel supports.
2. Separate motor for each condenser fan.
3. Fans shall be factory balanced and run before shipment.
4. Fan guards shall be heavy gauge, close meshed steel wire with a corrosion resistant PVC finish that shall be rated to pass a 675 hour salt spray test.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify mounting pads installations are completed to the proper point to allow installation of units. Do not proceed with Work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install condensing units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support:
   1. Install ground-mounted units on 4-inch-thick reinforced concrete pad, 4 inches larger on each side than condensing unit. Concrete is specified in Division 3. Coordinate installation of anchoring devices.

C. Air-Cooled Condensing Units: Connect refrigerant piping to unit; maintain required access to unit.
   1. Install furnished field-mounted accessories.
   2. Refrigerant piping sizes and configuration shall be selected/verified by the condensing unit manufacturer.

3.03 FIELD QUALITY CONTROL

A. Testing: Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

3.04 MANUFACTURER'S FIELD SERVICES

A. Prepare and start condensers under provisions of Section 01640 Start Up/Check Out/Manufacturer's Field Services for Contractor Furnished Equipment.

B. Supply service of factory-trained representative for a period of four (2) days per unit to supervise testing, dehydration and charging of systems, start-up, and instruction on operation and maintenance to Owner. Coordinate services of factory representative with installation of the Computer Room Air Conditioning Units specified in Section 15731.

C. Supply initial charge of refrigerant and oil.

3.05 DEMONSTRATION

A. Provide services of manufacturer's authorized service representative to provide start-up service and to instruct OWNER's personnel in operation and maintenance of condensing units.

B. Start-up condensing units in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

C. Train OWNER's personnel on start-up and shutdown procedures, troubleshooting procedures, servicing, and preventative maintenance schedule and procedures. Review with OWNER's personnel the data contained in the operating and maintenance manuals.

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END OF SECTION

SECTION 15682 AIR-COOLED WATER CHILLERS

PART 1- GENERAL

1.01 SUMMARY:

A. This section includes: Extent of air-cooled water chillers. Work required by this Section as indicated on Drawings and by requirements of this Section.

B. Types of air-cooled water chillers specified in this Section include the following:

1. Outdoor high efficiency unit located in chiller enclosure (CH-2)

C. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1, apply to Work of this Section.

1. Interlock wiring, specified as factory installed, is Work of this Section.
2. Starters & disconnects switch.

D. Refer to Division 16 for the following Work; not Work of this Section:

1. Power supply wiring from power source to power connection on units.
2. Interlock wiring between electrically operated units and between equipment and field-installed control devices.

1.02 SUBMITTALS:

A. Shop Drawings: Submit in accordance with Section 01300, Submittals covering the items included under this Section. Shop Drawing submittals shall include:

1. Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, furnished specialties and accessories, and installation and start-up instructions.
2. Submit manufacturer's assembly-type Shop Drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
3. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to the air-cooled chillers. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of air-cooled chillers and controls. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01730, operation and maintenance manuals for items included under this Section.

1.03 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air-cooled water chillers of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Conform to ANSI/ARI 590 code for testing and rating or reciprocating water chillers.
2. Conform to ANSI/UL 465 code for construction of reciprocating water chillers and provide UL label.

3. Conform to ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of reciprocating water chiller.

4. Conform to ANSI/ASHRAE 15 code for construction and operation of reciprocating water chiller.

5. Provide certification of inspection for conforming authority having jurisdiction approval.

1.04 DELIVERY, STORAGE, AND HANDLING:

A. Handle air-cooled water chillers and components carefully to prevent damage, breaking, denting, and scoring. Do not install damaged packaged heating and cooling units or components; replace with new.

B. Store units and components in clean, dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and installation instructions for unloading air-cooled water chillers and moving units to final location for installation.

1.05 TRAINING:

A. Provide services of manufacturers' technical representative to instruct Owner's personnel in operation and maintenance of the air cooled water chillers.

B. Schedule training with the Engineer, provide at least 7-day notice to the Engineer of training date.

C. All training shall be in accordance with Section -01664 – Training.

D. Provide (2) days of training instructions in operation and maintenance of the air cooled water chiller equipments and associated controls. Each day shall consist of four (4) hours of classrooms training and four hours (4) of in field training.

1.06 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship for parts and labor, for no less than five years from the date of Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

1.07 MAINTENANCE:

A. The manufacture shall furnish service and maintenance of complete assembly including material and labor for one (1) year from substantial completion. During the one (1) year period, the following items shall be included.

1. Quarterly operational inspections including "logging out" chiller to confirm control and sensor operation.

2. Condenser coil cleaning.

3. Oil analysis on both circuits.

4. Quarterly inspection reports which will be reviewed with the Owner.

PART 2 -PRODUCTS

2.01 MANUFACTURERS:

A. Subject to compliance with specified performance requirements and physical size envelope, the air cooled chiller shall be the product of the Trane Company and of the Model Number shown on the Drawings. No substitution is permitted.

2.02 AIR COOLED CHILLER:

A. General

1. Provide factory assembled and tested outdoor air-cooled liquid chillers consisting of compressors, condenser, evaporator, refrigeration accessories, control panel and all components required for complete operation. Construction rating shall be in accordance with ANSI/ARI 590. See schedules on drawings for equipment capacities.

2. Units shall be leak and pressure tested at 390 psig high side, 250 psig low side, then evacuated and charged. All Air-Cooled Chillers shall be factory testes prior to shipment. Packaged units shall ship with a full operating charge of oil and refrigerant. Unit panels, structural elements and control boxes shall be constructed of galvanized steel and mounted on a welded structural steel base. Unit panels and control boxes shall be finished with a baked on powder paint, and the structural base with air dry paint. All paint shall meet the requirements of outdoor equipment of the US Navy and other federal government agencies.

3. All motors shall be NEMA premium rated.

B. Evaporator

1. Provide a tube-in-shell heat exchanger design with internally and externally finned copper tubes roller expanded into the tube sheet. The evaporator shall be designed, tested and stamped in accordance with ASME for refrigerant side working pressure of 200 psig. The evaporator shall be designed for a water side working pressure of 150 psig. Water connections shall be grooved pipe. Each shell shall include a vent, a drain and fittings for temperature control sensors and be insulated with 3/4-inch equal insulation (K=0.26). Evaporator heaters with thermostat shall be provided to help protect the evaporator from freezing at ambient temperatures down to -20^{o}F). Factory installed flow switch shall be installed on a pipe stub in evaporator inlet.

C. Condenser and Fans

1. Air-cooled condenser coils shall have copper or aluminum fins mechanically bonded to internally finned seamless copper tubing. The condenser fins shall have a corrosion resistant coating applied. Coating shall be applied by fully submerging condenser in coating (dip method) to ensure all surfaces receive the coating. Coating shall be applied during or after manufacturer, but before delivery to the jobsite. Jobsite application of corrosion coating is unacceptable. The condenser coil shall have an integral sub-cooling circuit. Condensers shall be factory proof and leak tested at 506 psig. Direct vertical discharge condenser fans shall be balanced. Totally enclosed air over motors shall be provided to completely seal the motor windings to prevent exposure to ambient conditions. Three-phase condenser fan motors with permanently lubricated ball bearings and internal thermal overload protection shall be provided. Standard units shall start and operate between 25 to 115^{o}F (-4 to 46^{o}C) ambient.

D. Compressor and Lube Oil System

1. The compressor shall be rotary screw, semi-hermetic, direct drive, 3600 rpm, 60 Hz, with capacity control slide valve, a load/unload valve, rolling element bearings, differential refrigerant pressure oil pump and oil heater. The motor shall be a suction gas cooled, hermetically sealed, two-pole squirrel cage induction motor. Oil separator and filtration devices shall be provided separate from the compressor. Check valves in the compressor discharge and lube oil system and a solenoid valve in the lube system shall be provided.

E. Refrigeration Circuits

1. Each unit shall have two (2) refrigerant circuits, with one (1) or two (2) rotary screw compressors per circuit. Each refrigerant circuit shall include a compressor suction and

discharge service valve, liquid line shutoff valve, removable core filter, liquid line sight glass with moisture indicator, charging port and an electronic expansion valve. Fully modulating compressors and electronic expansion valves shall provide variable capacity modulation over the entire operating range.

F. Unit Controls

1. Controls shall be housed in an outdoor rated weather tight enclosure with removable plates to allow for connection of power wiring and remote interlocks. All controls, including sensors, shall be factory mounted and tested prior to shipment. Microcomputer controls shall provide all control functions including startup and shut down, leaving chilled water temperature control, evaporator flow proving, compressor and electronic expansion valve modulation, fan sequencing, anti-recycle logic, automatic lead/lag compressor starting and load limiting. The unit control module, utilizing Adaptive Control™ microprocessor, automatically shall take action to avoid unit shut down due to abnormal operating conditions associated with low refrigerant pressure, high condensing pressure and motor current overload. Should the abnormal operating condition continue until a protective limit is violated, the unit shall be shut down. Unit protective functions shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low refrigerant pressure, high refrigerant pressure, reverse rotation, compressor starting and running over current, phase low, phase imbalance, phase reversal, and loss of oil flow. A digital display shall indicate chilled water setpoint and leaving chilled water temperature. Current limit setpoint, evaporator and condenser refrigerant pressures, and electrical information shall be provided. Displays shall be visible on the unit without opening any panel doors. Power connections shall include main three phase power to the compressors, condenser fans and control power transformer. Provide a BACnet communications interface.

2. The unit shall be provided with all the hardware required to communicate the following control points to the existing Siemens EMCS.

   a. Chiller start/stop
   b. Chiller status (on/off)
   c. Chilled water temperature set point.
   d. Entering chilled water temperature
   e. Leaving chilled water temperature.
   f. Evaporator refrigerant pressure (each circuit).
   g. Evaporator refrigerant temperature (each circuit).
   h. Condenser refrigerant pressure (each circuit).
   i. Condenser refrigerant temperature (each circuit).
   j. All available fault codes and/or alarms.
   k. Energy consumption.

G. Starters

1. Starters shall be housed in a weather tight enclosure with removable cover plate to allow for customer connection of power wiring. Across-the-line starters shall be provided. Helical rotary screw compressors shall be full speed in one second when started across-the-line and have equivalent inrush with similar size reciprocating compressor with part wind starters.

H. Chilled Water Reset

1. Provide the control logic and factory installed sensors to reset leaving chilled water temperature. The setpoint shall be reset based on ambient temperature.

I. Flow Control

1. The factory installed flow switch shall be provided with the control logic and relays to turn the chilled water flow on and off as the chiller requires for operation and protection.

J. Electrical

1. Provide non-fused molded case disconnect switch (UL approved) to disconnect the chiller from main power pre-wired from the factory with terminal block power connections. The external operator handle shall be lockable.

K. Miscellaneous Accessories

1. Provide neoprene isolators to help eliminate vibrator transmission.

PART 3 -EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which packaged heating and cooling units are to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF AIR-COOLED WATER CHILLERS:

A. Install in accordance with manufacturer's instructions.

B. Align chiller package on steel foundations on the roofs as shown on the drawings.

C. Install units with vibration isolation.

D. Connect to electrical service. Refer to Electrical.

E. Connect to chilled water piping, refer to Section 15183. On inlet, provide thermometer well for temperature controller, thermometer well for temperature limit controller, flow switch, flexible pipe connector, and shut-off valve. On outlet, provide flexible pipe connector, shut-off and balancing valves.

F. Arrange piping fore easy dismantling to permit tube cleaning.

3.03 MANUFACTURER'S FIELD SERVICES:

A. Prepare and start systems under provisions of Section 01465.

B. Supply service of factory-trained representative for a period of two (2) days to supervise testing, dehydration and charging of machine, start-up, and instruction on operation and maintenance to Owner.

C. Supply initial charge of refrigerant and oil.

3.04 DEMONSTRATION:

A. Provide systems demonstration.

B. Demonstrate system operation and verify specified performance.

END OF SECTION

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SECTION 15731 COMPUTER ROOM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.01 SCOPE: Section includes requirements for computer room air conditioning systems (computer room air conditioning units –CRAC units). The systems shall be designed to maintain temperature and humidity conditions in the rooms containing electronic equipment. The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements of the room.

The provisions of Part 1, General Documents, and DIVISION 1, General Requirements, apply to this section. These general provisions for mechanical work shall apply to all sections of DIVISION 15

1.02 DESIGN REQUIREMENTS: The precision cooling system shall be a Liebert, self-contained, factory-assembled unit with Downflow air delivery. The system shall have a total cooling capacity of 202,500 BTU/H, (kW) with a sensible cooling capacity of 176,800 BTU/H (kW) Chilled Water & Air-Cooled Operation based on an entering air temperature of 75 *F (*C) dry bulb and 62.5 *F (*C) wet bulb. The unit is to be supplied with 460 volt 3 ph 60 Hz electrical service. 65,000 amps rms Short Circuit Current Rating.

1.03 SUBMITTALS:

A. Shop Drawings: Submit in accordance with Section 01300, Submittals covering the items included under this Section. Submit manufacturer’s data for approval before any work is commenced. Shop Drawing submittals shall include:

1. Submit manufacturer's technical product data/Shop Drawings, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), dimensions, required clearances, and methods of assembly of components, furnished specialties and accessories; and installation and start-up instructions. Include Single-Line Diagrams; Dimensional, Electrical and Capacity Data; Piping and Electrical Connection Drawings.

2. Wiring Diagrams: Submit ladder-type wiring diagrams for power and control wiring required for final installation of computer room air conditioning units and controls. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01730, operation and maintenance manuals for items included under this Section.

1.04 DELIVERY, STORAGE, AND HANDLING:

A. Handle computer room air conditioning units and components carefully to prevent damage. Follow manufacturer's written instructions for rigging. Replace damaged condensing units or components.

B. Store computer room air conditioning units and components in clean dry place off the ground. Protect from weather, water, and physical damage.

1.05 WARRANTY:

A. The MANUFACTURER shall warrant the EQUIPMENT, MATERIALS and PRODUCTS specified in this section against defective materials and workmanship with the MANUFACTURER’S standard warranty, but for no less than five years from the date of

Substantial Completion, and as described in Article 13 of Section 00700 - General Terms and Conditions.

B. The CONTRACTOR shall warrant the WORK against defects for one year from the date of Substantial Completion and as described in Article 13 of Section 00700 - General Terms and Conditions.

PART 2 – PRODUCTS

2.01 MANUFACTURERS: Subject to compliance with specified requirements, the Computer Room Air Conditioning Units (CRAC) shall be the product of the Liebert Company and be matched by the manufacturer to the new condensing units specified in Section 15670 to provide complete operating systems. No substitution is permitted.

2.02 COMPUTER ROOM AIR CONDITIONING UNITS (CRAC-1 AND CRAC-2):

A. Frame: The frame shall be MIG welded formed sheet metal. It shall be protected against corrosion using the autophoretic coating process. The frame shall be capable of being separated into three parts in the field to accommodate rigging through small spaces.

B. Downflow Air Supply: The supply air shall exit from the bottom of the unit, with the air scrolled towards the front of the unit.

C. Downflow Air Return: The return air shall enter the unit from the top.

D. Exterior Panels: The exterior panels shall be insulated with a minimum 1" (25mm), 1.5 lb. (0.68 kg) density fiber insulation. The main front panel shall have captive 1/4 turn fasteners. The main unit color shall be Light Gray Z-0430.

E. Filters, Downflow Unit: The filter chamber shall be located within the cabinet, and filters shall be removable from the top of the unit. Filters shall be arranged in a V-bank configuration to minimize air pressure drop.

F. Filters, 4": Filters shall be deep pleated 4" filters with a MERV 8 rating.

2.03 BLOWER SECTION: The fan section shall be designed for 10,000 CFM at an external static pressure of 0.2 in. wg. (49.8 Pa). The fans shall be the centrifugal type, double width double inlet and shall be statically and dynamically balanced as a completed assembly to a maximum vibration level of two mils in any plane. The shaft shall be heavy duty steel with self-aligning pillow block ball bearings with a minimum L3 life of 200,000 hours. The fans shall be located to draw air over the A-Frame coil to ensure even air distribution and maximum coil performance. A static regain duct shall be factory-installed to the bottom of the blower.

A. Motor: The fan motor shall be 7.5 hp (5.6 kW) at 1750 RPM @60Hz, mounted to a spring-tensioning base. The motor shall be removable from the front of the cabinet.

1. Premium Efficiency Motor: The fan motor shall be Open Drip-Proof, Premium efficiency and shall meet NEMA and EPACT minimum efficiency standards.

B. Drive Package: The motor sheave and fan pulley shall be double-width fixed pitch. Two belts, sized for 200% of the fan motor horsepower shall be provided with the drive package. An auto-tension system shall provide constant tension on the belts. Belts, shaft, blower bearings, sheave and pulley shall be warranted for five years.

2.04 HUMIDIFIER: A humidifier shall be factory-installed inside the unit. Bypass air slots shall be included to enable moisture to be absorbed into the air stream. The humidifier capacity shall be 22.0 lb/hr (kg/hr). The humidifier shall be removable from the front of the cabinet.

A. Infrared Humidifier: The humidifier shall be of the infrared type consisting of high intensity quartz lamps mounted above and out of the water supply. The humidifier pan shall be stainless steel and arranged to be removable without disconnecting high voltage electrical connections. The complete humidifier section shall be pre-piped, ready for field connection to water supply. The humidifier shall be equipped with an automatic water supply system and shall have an adjustable water-overfeed to prevent mineral precipitation. A high-water detector shall shut down the humidifier to prevent overflowing.

2.05 REHEAT: The precision cooling unit shall include a factory-installed reheat to control temperature during dehumidification.

A. Three -Stage Electric Reheat: The electric reheat coils shall be low watt density, 304/304 stainless steel fin tubular construction, protected by thermal safety switches, shall be 51,200BTU/ H, 15.0 kW, controlled in three stages. The reheat elements shall be removable from the front of the cabinet.

2.06 DUAL REFRIGERATION SYSTEM: Each unit shall include two (2) independent refrigeration circuits and shall include hot gas mufflers (semi-hermetic compressors units only), liquid line filter driers, refrigerant sight glass with moisture indicator, externally equalized expansion valves and liquid line solenoid valves. Compressors shall be located outside the airstream and shall be removable and serviceable from the front of the unit.

A. Dual Scroll Compressors: The compressor shall be scroll-type. The compressor shall be suction gas cooled motor, vibration isolators, thermal overloads, automatic reset high pressure switch with control lockout after three failures, pump down low pressure transducer, suction line strainer, rotalock service valves, a maximum operating speed of 3500 RPM.

B. Evaporator Coil: The evaporator coil shall be A-frame design with offset orientation and have 24.7 sq. ft. (m2) face area, three rows deep. It shall be constructed of rifled copper tubes and aluminum fins and have a maximum face velocity of 384.6 ft. per minute (m/s) at 9,600 CFM A stainless steel condensate drain pan shall be provided.

C. R-407C Refrigerant: The system shall be designed for use with R-407C refrigerant, which meets the EPA clean air act for phase-out of HCFC refrigerants. Refrigerant shall be field supplied and field charged on air-cooled systems.

2.07 ICOM MICROPROCESSOR CONTROL WITH LARGE GRAPHIC DISPLAY: The iCOM unit control shall be factory set-up for Intelligent Control which uses "fuzzy logic" and "expert systems" methods. Proportional and Tunable PID shall also be user selectable options. Internal unit component control shall include the following:

A. Compressor Short Cycle Control - Prevents compressor short-cycling and needless compressor wear.

B. System Auto Restart - The auto restart feature will automatically restart the system after a power failure. Time delay is programmable.

C. Sequential Load Activation - On initial startup or restart after power failure, each operational load is sequenced with a minimum of one second delay to minimize total inrush current.

D. Predictive Humidity Control - calculates the moisture content in the room and prevents unnecessary humidification and dehumidification cycles by responding to changes in dew point temperature.

E. The iCOM control shall be compatible with all Liebert remote monitoring and control devices. Provide a BACnet communications interface.

F. The iCOM control processor shall be microprocessor based with a 128x64 dot matrix graphic front monitor display and control keys for user inputs mounted in an ergonomic, esthetically pleasing housing. The display & housing shall be viewable while the unit panels are open or closed. The controls shall be menu driven. The display shall be organized into three main sections: User Menus, Service Menus and Advanced Menus. The system shall display user menus for: active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in percent of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes within the service menus. Service menus shall include: setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode. A password shall be required to access the advanced menus which include the factory settings and password menus.

G. The User Menus Shall be Defined as Follows:

1. Active Alarms: Unit memory shall hold the 200 most recent alarms with time and date stamp for each alarm.

2. Event Log: Unit memory shall hold the 400 most recent events with id number, time and date stamp for each event.

3. Graphic Data View: Eight graphic records shall be available: return air temperature, return air humidity, supply air temperature, outdoor temperature and four custom graphs.

4. Unit View - Status Overview: Simple or Graphical "Unit View" summary displays shall include temperature and humidity values, active functions (and percent of operation) and any alarms of the host unit.

5. Total Run Hours: Menu shall display accumulative component operating hours for major components including compressors, Econ-O-Coil (FC), fan motor, humidifier and reheat.

6. Various Sensors: Menu shall allow setup and display of optional custom sensors. The control shall include four customer accessible analog inputs for sensors provided by others. The analog inputs shall accept a 4 to 20 mA signal. The user shall be able to change the input to 0 to 5VDC or 0 to 10VDC if desired. The gains for each analog input shall be programmable from the front display. The analog inputs shall be able to be monitored from the front display.

7. Display Setup: Customer shall pre-select the desired grouping of display languages at the time of the order from the following choices:

   Group 1: English, French, Italian, Spanish, German
   Group 2: English, Russian, Greek
   Group 3: English, Japanese, Chinese, Arabic

8. Service Contacts: Menu shall allow display of local service contact name and phone number. The Service Menus Shall be Defined as Follows:

   Setpoints: Menu shall allow set points within the following ranges:

   Temperature Set point 65-85*F (18-29*C)*
   Temperature Sensitivity +1-10*F (0.6-5.6*C)
   Humidity Set point 20-80% RH*
   Humidity Sensitivity 1-30% RH
   High Temperature Alarm 35-90*F (2-32*C)
   Low Temperature Alarm 35-90*F (2-32*C)
   High Humidity Alarm 15-85% RH
   Low Humidity Alarm 15-85% RH
   * The microprocessor may be set within these ranges, however, the unit may not be able to control to extreme combinations of temperature and humidity.

   Standby Settings/Lead-Lag: Menu shall allow planned rotation or emergency rotation of operating and standby units.

   Timers/Sleep Mode: Menu shall allow various customer settings for turning on/off unit.

9. Alarm Setup: Menu shall allow customer settings for alarm notification (audible/local/remote). The following alarms shall be available:

   High Temperature
   Low Temperature
   High Humidity
   Low Humidity
   Short Cycle
   Compressor Overload (Optional)
   Main Fan Overload (Optional)
   Humidifier Problem
   High Head Pressure
   Change Filter
   Loss of Air Flow
   Low Suction Pressure
   Loss of Power
   Custom Alarm (#1 to #4)

10. Custom alarms are four customer accessible alarm inputs to be indicated on the front panel. Custom alarms can be identified with prepared (programmed) alarm labels for the following frequently used inputs:

    Water Under Floor
    Smoke Detected
    Loss of Water Flow
    Standby Unit On

11. User customized text can be entered for two of the four custom alarms. Each alarm (unit and custom) can be separately enabled or disabled, selected activate the common alarm and programmed for a time delay of 0 to 255 seconds.

12. Audible Alarm: The audible alarm shall annunciate any alarm that is enabled by the operator.

13. Common Alarm: A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.

14. Remote Monitoring: All alarms shall be communicated to the Liebert monitoring system with the following information: Date and time of occurrence, unit number and present temperature and humidity.

15. Sensor Calibration: Menu shall allow unit sensors to be calibrated with external sensors.

16. Maintenance/Wellness Settings: Menu shall allow reporting of potential component problems before they occur.

17. Options Setup: Menu shall provide operation settings for the installed components. System/Network Setup: Menu shall allow Unit to Unit (U2U) communication and setup for teamwork modes of operation (up to 32 units).

18. Teamwork Modes of Operation - Saves energy by preventing operation of units in opposite modes multiple units.

19. Auxiliary Boards: Menu shall allow setup of optional expansion boards.

20. Diagnostics/Service Mode: The iCOM control shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as on or off at the front display. Control outputs shall be able to be turned on or off from the front display without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.

21. Advanced Menus:

    a. Factory Settings: Configuration settings shall be factory-set based on the pre-defined component operation.

    b. Change Passwords: Menu shall allow new passwords to be set or changed.

H. iCOM Microprocessor Control With Large Graphic Display: The iCOM unit control with large graphic display shall include all of the features as the iCOM with small graphic display, except that it includes a larger graphical display and shall include the additional features of: System View, Spare Parts List, Unit Diary and Online Manual.

1. The iCOM control processor shall be microprocessor based with a 320x240 dot matrix graphic front monitor display panel and control keys for user inputs mounted in an ergonomic, esthetically pleasing housing.

2. System View - Status Overview: "System View" shall display a summary of operation for the total number of operating units within a Unit-to-Unit (U2U) configuration.

3. Spare Parts List: Menu shall include a list of critical spare parts, their quantity and respective part numbers.

4. Setup Assistant: Menu shall include an online manual "assistant" for guidance during initial setup and routine maintenance.

5. Unit Diary: Menu shall include a free field area within the unit memory where unit history may be stored for reference.

2.08 DUAL COOLING SOURCE: The dual cooling source system shall consist of an air cooled compressorized system with the addition of a chilled water coil, a modulating control valve and a comparative temperature sensor. The system shall be able to function either as a modulating chilled water system or as a compressorized system, or a combination of both. The primary mode of cooling shall be chilled water. Switchover between the two cooling modes shall be performed automatically by the microprocessor control.

A. Dual Cooling Source Control Valve: The water circuit shall include a three-way modulating valve. The microprocessor positions the valve in response to room conditions. Cooling capacity will be controlled by bypassing chilled water around the coil. The modulating valve travel for dehumidification shall be proportional.

2.09 NON-LOCKING DISCONNECT SWITCH: The manual disconnect switch shall be mounted in the high voltage section of the electrical panel. The switch shall be accessible with the door closed.

A. Smoke Sensor: The smoke sensor shall sample the return air, shutdown the unit upon detection, and send visual and audible alarm. Dry contacts shall also be provided. This smoke sensor is not intended to function as, or replace, any room smoke detection system that may be required by local or national codes. The smoke sensor shall include a supervision contact closure.

2.10 AIR-COOLED CONDENSER: Provide Liebert manufactured outdoor air cooled condensers in accordance with Section 15670 Condensing Units.

2.11 LIQUI-TECT SENSORS: Provide One (quantity) solid state water sensors under the raised floor.

2.12 FLOOR STAND: The floor stand shall be constructed of a welded tubular steel frame. The floor stand shall have adjustable legs with vibration isolation pads. The floor stand shall be 12" inches (mm) high.

A. Floor Stand Turning Vane: A turning vane shall be supplied with the floor stand.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. General: Install computer room air conditioning units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated and maintain manufacturer's recommended clearances.

B. The CRAC units shall be replaced on weekends, one unit at a time. The north stair shall be used for access and installation of the CRAC units. After getting the CRAC units inside the building in the EOC operations room, the CONTRACTOR shall allow the room temperature to stabilize prior to entering the Data Center. Following installation and start-up of the first CRAC Unit, the CONTRACTOR shall allow the new CRAC unit and Data Center temperature and humidity to stabilize for a minimum of one week prior to replacing the second unit. Refer to Section 01010 Summary of Work for further details on sequencing the Work

C. Electrical Wiring: Install and connect electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's electrical connection

diagram submittal to electrical CONTRACTOR. Connect the new Liebert unit controllers to the existing Liebert nVSA network switch to communicate to existing unit.

D. Piping Connections: Install and connect devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's piping connection diagram submittal to piping CONTRACTOR.

E. Field Quality Control: Startup computer room air conditioning units in accordance with manufacturer's startup instructions. Test controls and demonstrate compliance with requirements. These specifications describe requirements for a computer room precision cooling system. The system shall be designed to maintain temperature and humidity conditions in the rooms containing electronic equipment. The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements.

F. Coordinate installation of the CRAC units with the installation of the air cooled condensing units and the refrigerant piping modifications and installation.

G. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

3.02 MANUFACTURER'S FIELD SERVICES: Prepare and start computer room air conditioning units under provisions of Section 01640 Start-up/Checkout/ Manufacturer's Field Services for CONTRACTOR Furnished Equipment.

A. Supply service of factory trained representative for a period of four (4) days per unit to supervise installation testing, dehydration and charging of systems, start-up, and instruction on operation and maintenance to the OWNER. Factory representative shall be available to support weekend work as noted herein.

B. Supply initial charge of refrigerant and oil.

3.03 DEMONSTRATION: Provide services of manufacturer's authorized service representative to provide start-up service and to instruct OWNER's personnel in operation and maintenance of computer room air conditioning units.

A. Train OWNER's personnel on start-up and shutdown procedures, troubleshooting procedures, servicing, and preventative maintenance schedule and procedures. Review with OWNER's personnel the data contained in the operating and maintenance manuals.

SECTION 15900 ENERGY MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Energy Management and Control System (EMCS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

B. The proposed DDC system shall be a direct extension of the existing South Florida Water Management District ("SFWMD") Headquarters Campus energy management system - Siemens Industry, Inc., Building Technologies Division APOGEE System. The DDC system shall communicate to the existing SFWMD energy management system Server - APOGEE Insight.

C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.

D. EMCS manufacturer shall be responsible for all EMCS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.

1.02 WORK BY OTHERS

A. Mechanical contractor installs all wells, valves, taps, dampers, flow stations, etc. furnished by EMCS manufacturer.

B. Electrical Contractor provides:

1. 120V power to all EMCS and/or temperature control panels

2. Wiring of all power feeds through all disconnect starters to electrical motor

3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by EMCS manufacturer

4. Wiring of any electrical sub-metering devices furnished by EMCS manufacturer.

C. Products furnished but not installed under this section

1. Section 15183 - Hydronic Piping:

a. Control Valves
b. Temperature Sensor Wells and Sockets
c. Taps for Flow Meters and Pressure Transmitters

2. Section 15185 - Refrigerant Piping:

a. Pressure and Temperature Sensor Wells and Sockets

D. Products installed but not furnished under this section

1. Section 15682 – Air Cooled Water Chillers:

a. Pressure Transmitters
b. Temperature Transmitters

c. Power Transmitters
d. Refrigerant Leak Detectors

1.03 RELATED WORK

A. Division 01000 - General and Special Conditions
B. Division 15000 - Mechanical
C. Division 16000 - Electrical

1.04 QUALITY ASSURANCE

A. The EMCS system shall be designed and installed, commissioned and serviced by the local Siemens Industry, Inc., Building Technologies Division factory owned office. Distributors or licensed installing contractors are not acceptable.

The manufacturer shall provide an experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the B.M.S.

The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BMS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of B.M.S. systems similar in size and complexity to this project.

B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

C. All EMCS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX. and be so listed at the time of bid. All floor level controllers shall comply, at a minimum, with UL Standard UL 91 6category PAZX; Standard UL 864, categories UDTZ, and QVAX. and be so listed at the time of Bid.

D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

E. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

F. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network.

Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

1.05 SUBMITTALS

A. Submit five (5) complete sets of documentation in the following phased delivery schedule:

1. Valve and damper schedules

2. Equipment data cut sheets

3. System schematics, including:

   a. sequence of operations
   b. point names
   c. point addresses
   d. interface wiring diagrams
   e. panel layouts.
   f. system riser diagrams

4. Auto-CAD compatible as-built drawings

B. Prior to final completion, submit operation and maintenance manuals, consisting of the following:

1. Index sheet, listing contents in alphabetical order

2. Manufacturer's equipment parts list of all functional components of the system, Auto-CAD disk of system schematics, including wiring diagrams

3. Description of sequence of operations

4. As-Built interconnection wiring diagrams

5. Operator's Manual

6. Trunk cable schematic showing remote electronic panel locations, and all trunk data

7. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)

8. Conduit routing diagrams

1.06 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire EMCS system for a period of one year after beneficial use.

B. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

C. The on-line support services shall allow the local EMCS subcontractor to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

D. If the problem cannot be resolved on-line by the local office, the national office of the building automation system manufacturer shall have the same capabilities for remote connection to the facility. If the problem cannot be resolved with on-line support services, the EMCS manufacturer shall dispatch the appropriate personnel to the job site to resolve the problem within 3 hours of the time that the problem is reported.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Siemens Industry, Inc., Building Technologies Division APOGEE System. No substitutions are permitted.

2.02 NETWORKING COMMUNICATIONS

A. The design of the EMCS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a district-wide (Management Level Network) Ethernet network based on TCP/IP protocol, high performance peer-to-peer building level network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.

B. The design of EMCS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.

C. System shall have the capability to be an OPC Server for dynamic communication with OPC Clients over an Ethernet network. At a minimum, the following must be supported:

1. Data Access 1.0 (96), 1.0A (97) and 2.0 (11/98)
2. Alarms & Events 1.0 (1/99)

D. Peer-to-Peer Building Level Network:

1. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.

2. The peer-to-peer network shall support a minimum of 100 DDC controllers and PC workstations

3. Each PC workstation shall support a minimum of 4 peer-to-peer networks hardwired or dial up, or up to 32 peer-to-peer networks using Ethernet.

4. The system shall support integration of third party systems (fire alarm, security, lighting, PCL, chiller, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control. All exchange points shall have full system functionality as specified herein for hardwired points.

5. Field panels must be capable of integration with open standards including Modbus, BACnet, and Lonworks as well as with third party devices via existing vendor protocols.

6. Telecommunication Capability:

a. Auto-dial/auto-answer communications shall be provided to allow DDC Controllers to communicate with remote operator stations and/or remote terminals via telephone lines, as indicated in the sequence of operations.

b. Auto-dial DDC Controllers shall automatically place calls to workstations to report alarms or other significant events. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers.

c. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines to automatically answer calls from remote DDC or HVAC Mechanical Equipment Controllers shall be inherent in the Controller. The use of additional firmware or software is not acceptable. The fact that communications are taking place with remote DDC or HVAC & Mechanical Equipment Controllers over telephone lines shall be completely transparent to an operator.

d. Multiple modems shall be supported by DDC or HVAC & Mechanical Equipment Controllers on the Peer-to-Peer Network to ensure continuous communication to workstation.

E. Management Level Network

1. All PC and Laptop Workstations shall simultaneously direct connect to the Ethernet and Building Level Network without the use of an interposing device

2. Operator Workstations shall be capable of simultaneous direct connection and communication with BACnet, OPC, and Apogee networks without the use of interposing devices.

3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.

4. When appropriate, any controller residing on the peer-to-peer building level networks shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.

5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet, as well as, directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network.

6. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in an alarm notification at the PC.

7. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3

8. Access to the system database shall be available from any client workstation on the Management Level Network.

2.03 DDC CONTROLLER FLOOR LEVEL NETWORK:

A. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.04 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLERS

A. The DDC & HVAC Mechanical Equipment Controllers shall reside on the Building Level Network.

B. DDC & HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC & HVAC Mechanical Equipment Controllers which require different programming language or tools on a network are not acceptable.

C. DDC & HVAC Mechanical Equipment Controllers which do not meet the functions specified in Section 2.4.1 and Section 2.5 for DDC Controllers or Section 2.4.2 and Section 2.5 for HVAC Mechanical Equipment Controllers are not acceptable.

2.04.01 DDC CONTROLLER

A. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three (3) Floor Level Application Specific Controller Device Networks.

B. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Dial-up communications
9. Manual override monitoring

C. Each DDC Controller shall support firmware upgrades without the need to replace hardware.

D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

E. DDC Controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

F. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.

1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

G. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

- RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
- Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
- Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
- Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:

- IEEE Standard 587-1980
- UL 864 Supply Line Transients
- Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

J. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.

1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.

2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

K. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02. It is intended that each unique system be provided with its own point resident DDC Controller.

2.04.2 HVAC MECHANICAL EQUIPMENT CONTROLLERS

A. HVAC Mechanical Equipment Controllers shall be a 12-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors.

B. Each HVAC Mechanical Controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Dial-up communications

C. Each HVAC Mechanical Equipment Controller shall support firmware upgrades without the need to replace hardware.

D. HVAC Mechanical Equipment Controllers shall provide a RS-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.

E. HVAC Mechanical Equipment Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

F. Each HVAC Mechanical Equipment Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The HVAC Mechanical Equipment Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

G. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

- RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
- Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
- Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
- Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
  Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
- IEEE Standard 587-1980
- UL 864 Supply Line Transients
- Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

H. In the event of the loss of normal power, there shall be an orderly shutdown of all HVAC Mechanical Equipment Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the HVAC Mechanical Equipment Controller shall automatically resume full operation without manual intervention.

2. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of reloading the HVAC Mechanical Equipment Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

2.05 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLER RESIDENT SOFTWARE FEATURES

A. General:

1. The software programs specified in this Section shall be provided as an integral part of DDC and HVAC Mechanical Equipment Controllers and shall not be dependent upon any higher level computer for execution.

2. All points shall be identified by up to 30 character point name and 16 character point descriptor. The same names shall be used at the PC workstation.

3. All digital points shall have user defined two-state status indication (descriptors with minimum of eight (8) characters allowed per state (i.e. summer/winter)).

B. Control Software Description:

1. The DDC and HVAC Mechanical Equipment Controllers shall have the ability to perform the following pre-tested control algorithms:

   a. Two-position control
   b. Proportional control
   c. Proportional plus integral control
   d. Proportional, integral, plus derivative control
   e. Automatic tuning of control loops

C. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.

1. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down

HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.

a. The SSTO program shall operate in both the heating and cooling seasons.

1) It shall be possible to apply the SSTO program to individual fan systems.

2) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.

b. The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.

2. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.

a. It shall be possible to individually command a point or group of points.

b. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.

c. The operator shall be able to define the following information:

1) Time, day
2) Commands such as on, off, auto, and so forth.
3) Time delays between successive commands.
4) There shall be provisions for manual overriding of each schedule by an appropriate operator.

d. It shall be possible to schedule events up to one year in advance.

1) Scheduling shall be calendar based.
2) Holidays shall allow for different schedules.

3. Enthalpy switchover (economizer) .The Energy Management Control Software (EMCS) will control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the EMCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

4. Temperature-compensated duty cycling.

a. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.

b. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

5. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

6. Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.

7. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.

    a. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.

    b. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.

    c. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.

    d. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

D. DDC and HVAC Mechanical Equipment Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.

2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

3. DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.

4. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC Mechanical Equipment Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC and HVAC Mechanical Equipment Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC and HVAC Mechanical Equipment Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hour’s destinations) or based on priority.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.

F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.

1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC and HVAC Mechanical Equipment Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided. Each DDC and HVAC Mechanical Equipment Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples. All trend data shall be available for transfer to a Workstation without manual intervention.

2. DDC and HVAC Mechanical Equipment Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.

a. Loop tuning shall be capable of being initiated either locally at the DDC and HVAC Mechanical Equipment Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

G. DDC and HVAC Mechanical Equipment Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

H. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstation without dependence upon a central or intermediate processing device. The peer to peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

I. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

2.06 FLOOR LEVEL NETWORK APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through Floor Level LAN Device Networks.

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as a minimum:

1. Central System Controllers

2. Terminal Equipment Controllers

C. Central System Controllers:

1. Provide for control of central HVAC systems and equipment including, but not limited to, the following:

   a. Rooftop units
   b. Packaged air handling units
   c. Built-up air handling systems
   d. Chilled and condenser water systems
   e. Steam and hot water systems

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden.

3. Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.

4. All programs shall be field-customized to meet the user's exact control strategy requirements. Central System controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide DDC Controllers for all central equipment in order to meet custom control strategy requirements.

5. Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a DDC Controller to meet the specified functionality.

6. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs.

D. Terminal Equipment Controllers:

1. Provide for control of each piece of equipment, including, but not limited to, the following:

   a. Variable Air Volume (VAV) boxes
   b. Constant Air Volume (CAV) boxes
   c. Dual Duct Terminal Boxes
   d. Unit Conditioners
   e. Heat Pumps
   f. Unit Ventilators
   g. Room Pressurization

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 3-15 psi pneumatic, 0-10v, allowing for interface to a variety of modulating actuators.

3. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable

E. Digital Energy Monitors:

1. DDC system shall have capability for three phase digital watt-meters with pre-wired CTs. All watt-meter electronics shall be housed within the CTs. CTs shall include sizes capable of mounting directly on a power bus. Diagnostics visible to the installing electrician (without a operator tool) shall indicate: proper operation, mis-wiring or low power-factor, device malfunction, and over-load condition. The meters shall include the following:

   a. The device shall be UL Listed, and shall comply with ANSI C12.1 accuracy specification. The minimum CT/meter combined accuracy shall be no greater than 1% of reading over the range of 5% to 100% of rated load. The meter shall not require calibration.

   b. The wattmeter shall directly connect to power from 208 through 480 with no potential transformer. In-line fuses for each voltage tap phase shall be included.

   c. The wattmeter CTs shall be split-core and at minimum be sized to accommodate loads ranging from 100 to 2400 Amps. The CTs shall be volt-signal type, and shall not require shorting blocks.

   d. The wattmeter shall reside directly on the Floor Level Network along with other FLN devices. Data transferred shall include.

      - kW & kWH
      - Consumption
      - Demand
      - Power Factor
      - Current
      - Voltage
      - Apparent Power
      - Reactive Power

2.07 DYNAMIC COLOR GRAPHIC DISPLAYS

A. Create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including the new 156 ton chilled water system and floor level terminal units. Displays shall be provided by the EMCS contractor as indicated on the drawings to optimize system performance, analysis and speed alarm recognition.

B. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.

C. Dynamic temperature values, energy values, flow values, pressure values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

1. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.

2. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

3. Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or setpoint.

4. State text for digital points can be defined up to eight characters.

D. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

E. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

F. Off the shelf graphic software, Micrografx Designer or Coral Draw software shall be provided to allow the user to add, modify or delete system graphic displays.

G. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.

H. A dynamic display of the site specific architecture showing status of controllers, PC workstations and networks shall be provided.

2.08 LOCAL USER DISPLAY

Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.

A. The display shall use the same security password and access rights for points in the display as is used in the associated controller.

B. The LCD display shall be a minimum of a 2 line 40 character display.

C. The LCD display shall include the full point name, value (numeric, digital or state text), point priority and alarm status on one screen.

D. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.

E. The display shall be mounted either on the door of the enclosure or remote from the controller

2.09 FIELD DEVICES

A. Provide instrumentation as required to make a fully functional system for monitoring, control or optimization functions.

B. Insertion Magnetic Flow Meters (Onicon Series F-3500 with Onicon System 10 BTU transmitter)

Power Supply	24 VAC from new Apogee EMCS panel
Accuracy	± 1% of Actual Reading over a flow range of 2 to 20 feet/sec.
Maximum Operating Pressure	400 PSI
Output Signals	One 4–20mA plus Modbus RS-485 half-duplex communications
Input Signals	Two temperature transmitters, 4-20mA (loop-powered from the System 10 BTU transmitter)

C. Pressure to Current Transmitters

Range	3 to 50 psig
Output Signal	4 – 20 mA, loop powered
Accuracy	± 1% of full scale

D. Temperature Transmitters

Range	32-200^{O}F
Output Signal	4 – 20 mA, loop powered
Accuracy	± 1% of full scale

PART 3 - EXECUTION

3.01 PROJECT MANAGEMENT

A. Provide a designated project manager who will be responsible for the following:

1. Construct and maintain project schedule
2. On-site coordination with all applicable trades, subcontractors, and other integration vendors
3. Authorized to accept and execute orders or instructions from owner/architect
4. Attend project meetings as necessary to avoid conflicts and delays
5. Make necessary field decisions relating to this scope of work
6. Coordination/Single point of contact

3.02 SEQUENCE OF OPERATION

A. Refer to mechanical drawings.

3.03 POINT SCHEDULE

A. The contractor shall collaborate with the owner directly to determine the owner's preference for naming conventions, etc. before entering the data in to the system.

3.04 START-UP AND COMMISSIONING

A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the manufacturer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

C. After manufacturer has completed system start-up and commissioning. Joint commissioning of integrated system segments shall be completed.

3.05 ELECTRICAL WIRING AND MATERIALS

A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. All wiring in mechanical rooms and exposed areas shall be installed in conduit. Plenum rated cable is acceptable above ceilings where local building codes allow.

B. Provide wiring between thermostats, aquastats and unit heater motors, all control and alarm wiring for all control and alarm devices for all Sections of Specifications.

C. Provide status function conduit and wiring for equipment covered under this Section.

D. Provide conduit and wiring between the B.M.S. panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit.

E. Provide conduit and control wiring for devices specified in this Section.

F. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in B.M.S. panels located in the vicinity of motor control centers.

G. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and B.M.S. panels, as shown on the drawings or as specified.

H. All wiring to be compliant to local building code and the NEC.

I. Provide electrical wall box and conduit sleeve for all wall mounted devices.

3.06 PERFORMANCE

A. Unless stated otherwise, control temperatures within plus or minus 2^{o}F, humidity within plus or minus 3% of the set point, and static pressure within 10% of set point.

3.07 COMMISSIONING, TESTING AND ACCEPTANCE

A. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance testing. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:

    a. Sensor accuracy at 10, 50 and 90% of range.
    b. Sensor range.
    c. Verify analog limit and binary alarm reporting.
    d. Point value reporting.
    e. Binary alarm and switch settings.
    f. Actuator ranges.
    g. Fail safe operation on loss of control signal, electric power, network communications.

B. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

C. After all BMS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:

1. Data communication, both normal and failure modes.
2. Fully loaded system response time.
3. Impact of component failures on system performance and system operation.
4. Time/Date changes.
5. End of month/ end of year operation.
6. Season changeover.
7. Global application programs and point sharing.
8. System backup and reloading.
9. System status displays.
10. Diagnostic functions.
11. Power failure routines.
12. Battery backup.
13. Smoke Control, stair pressurization, stair, vents, in concert with Fire Alarm System testing.
14. Testing of all electrical and HVAC systems with other division of work.

D. Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and the system performance does not degrade over time.

E. Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate all system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

F. The contractor shall supply all instruments for testing.

1. All test instruments shall be submitted for approval.

Test Instrument Accuracy:

Temperature:	1/4F or 1/2% full scale, whichever is less.
Pressure:	High Pressure (psi): ½ psi or 1/2% full scale, whichever is less.
Low Pressure: (in w.c.)	1/2% of full scale
Humidity:	2% RH
Electrical:	1/4% full scale

G. After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

3.08 TRAINING

A. The manufacturer shall provide factory trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays.

B. Provide four (4) hours of training for Owner's designated operating personnel. Training shall include:

1. Explanation of drawings, operations and maintenance manuals
2. Walk-through of the job to locate control components
3. Operator workstation and peripherals
4. DDC controller and ASC operation/function
5. Operator control functions including graphic generation and field panel programming
6. Explanation of adjustment, calibration and replacement procedures
7. Student binder with training modules

END OF SECTION

SECTION 15950 TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SCOPE

A. Section Includes: Requirements and procedures for total mechanical systems testing, adjusting, and balancing. Requirements include:

1. Measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications.

2. Recording and reporting the results.

B. Work includes complete testing, adjusting and balancing of the new chilled water system including new pumps, new chiller and all existing air handling units and computer room air conditioning (CRAC) units which use chilled water as shown on the Chilled Water Flow Diagram. The complete piping system shall be balanced including the new and existing chilled water piping which forms the chilled water system as shown on the drawings.

C. Test, adjust, and balance the following mechanical systems:

1. Hydronic systems.

D. This Section does not include:

1. Specifications for materials for patching mechanical systems.

2. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.

3. Requirements and procedures for piping and ductwork systems leakage tests.

4. Testing and balancing of air handling systems.

E. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1, apply to Work of this Section.

1.02 DEFINITIONS

A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. The balance of water distribution.

2. Adjustment of total system to provide design quantities.

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate at the terminal equipment.

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. There are supply inlets on water terminals, and return outlets on water terminals.

H. Main: Pipe containing the system's major or entire fluid flow.

I. Sub main: Pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch main: Pipe serving two or more terminals.

K. Branch: Pipe serving a single terminal.

1.03 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01300, Submittals covering the items included under this Section. Shop Drawing submittals shall include:

1. Agency Data: Proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified in Quality Assurance Article.

2. Engineer and Technicians Data: Proof that the Test and Balance Engineer assigned to supervise the procedures and the technicians proposed to perform the procedures meet the qualifications specified below.

3. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this Project.

B. Certified Reports:

1. Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards, are an accurate representation of how the systems have been installed, are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures, and are an accurate record of all final quantities measured to establish normal operating values of the systems. Follow the procedures and format specified below:

a. Reports: Upon completion of testing, adjusting, and balancing procedures, prepare a testing and balancing report. Reports must be complete, factual, accurate, and legible. Organize and format reports as specified below. Submit four complete sets of reports to ENGINEER for evaluation and approval.

b. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced,

vinyl, 3-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:

1) General Information and Summary.

2) Hydronic Systems.

c. Report Contents: Provide the following minimum information, forms, and data:

1) General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, CONTRACTOR, OWNER, ENGINEER, and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentations used for the procedures along with the proof of calibration.

2) The remainder of the report shall contain the appropriate forms containing, as a minimum, the information indicated on the standard report forms prepared by the AABC and NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form. Diagrams are not required for air systems containing one or two terminals.

C. Calibration Reports:

1. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of 6 months prior to starting Project.

1.04 QUALITY ASSURANCE

A. Agency Qualifications:

1. Employ the services of an independent testing, adjusting, and balancing agency to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above to produce the design objectives. Services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

2. An independent testing, adjusting, and balancing agency certified by Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB), in those testing and balancing disciples required for this Project and having at least one Professional Engineer registered in the State in which the services are to be performed, certified by AABC or NEBB as a Test and Balance Engineer.

B. Codes and Standards:

1. AABC: "National Standards for Total System Balance."

2. ASHRAE: ASHRAE Handbook, Current Edition, Testing, Adjusting, and Balancing.

C. Pre-balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the representatives of installers of the mechanical systems. The objective

of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

1.05 PROJECT CONDITIONS

A. Systems Operation: Systems shall be fully operational prior to beginning procedures.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PRELIMINARY PROCEDURES FOR HYDRONIC SYSTEM BALANCING

A. Before operating the system perform these steps:

1. Open valves to full open position.
2. Remove and clean all strainers.
3. Examine hydronic systems and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Clean and set automatic fill valves for required system pressure.
6. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
7. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
8. Set temperature controls so all coils are calling for full flow.
9. Check operation of automatic bypass valves (where applicable).
10. Lubricate all motors and bearings.

3.02 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured. Apply instrument as recommended by the manufacturer.

D. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

E. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until two consecutive identical values are obtained.

F. Take all reading with the eye at the level of the indicated value to prevent parallax.

G. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

H. Take measurements in the system where best suited to the task.

3.03 PERFORMING TESTING, ADJUSTING, AND BALANCING

A. Perform testing and balancing procedures on each system identified in accordance with the detailed procedures outlined in the referenced standards.

B. Mark equipment settings, valve indicators, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.

C. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.04 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.05 BALANCING TOLERANCES

A. Adjust hydronic systems to plus or minus five (5) percent of design conditions indicated.

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END OF SECTION 15950